Developing evidence-based risk communication strategies to promote protective health behaviours in nuclear emergencies

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Abstract

Catastrophic terror attacks, including the use of a nuclear device, are amongst the highest priority risks to the UK according to the 2017 National Risk Register. A nuclear attack could result in mass fatalities, contamination of people and buildings, widespread infrastructure damage, and interruption to the supply of essential goods (Cabinet Office, 2017i).

Despite the severity of a nuclear incident, there are actions which members of the public can take to reduce the risk to themselves and others. These include preparedness actions, such as assembling an emergency supply kit (Taylor et al., 2011), and taking actions following a nuclear attack, such as sheltering-in-place (e.g. Florig & Fischhoff, 2007; Khripunov, 2010).

To understand more about factors which influence engagement with pre-nuclear incident information, and to examine ways to overcome potential barriers, I conducted multi-phase, mixed methods research involving a systematic review of relevant literature, scenario-based focus groups and two surveys.

In my systematic review I found preparedness for nuclear disasters to be low, though it is notable that nuclear-specific studies have focused on nuclear power plant disasters. Outcomes of these studies also show a mixed-picture of adherence to recommended countermeasures such as instructions to shelter-in-place or to evacuate. A wide range of preferences were expressed for pre-incident communications including for communicating source and for method of communications.

Focus groups were split into groups of London residents and groups residing close to Hinkley Point nuclear plant. Little difference was found across all groups for factors such as perceived risk of a nuclear disaster (attack or radiation leak), nor was there a strong desire to receive pre-nuclear incident risk communications, unless an attack was known to be imminent. Notably, groups suggested that a nuclear risk communication campaign would be received poorly unless it was normalised in society, such as by being introduced slowly through institutions such as workplaces or schools. Groups also suggested that levels of trust in the source of information is not important if suggested countermeasures are felt to not be efficacious.

My surveys were conducted with the UK public and with the Hawai'i public following the ballistic missile false alert that Hawai'i experienced in January 2018. Low levels of deliberate adherence to the missile alert recommendation to shelter was found in the Hawaiian public, though the timing of the warning meant that most were already at home and so remained there. I found preparedness of both UK and Hawai'i participants, in terms of owning

recommended items, to be higher than is suggested by previous literature; however, preparedness was for general disasters, not for nuclear disaster specifically. Individuals who felt nuclear disaster to be more likely to occur were more prepared but less likely to desire preparedness communications. There was also low belief in the efficacy of recommended countermeasures (such as sheltering). A critical finding of the Hawai'i-based survey, the only study of its kind to investigate preparedness with a population warned of an incoming nuclear attack, was the early warning confirmation sought. This need appeared to drive people to social media and friends and family. Insights such as this and others gained throughout this thesis are crucial for public health authorities in their preparedness and response planning.

Overall, the outcomes of this thesis suggest that increased engagement with pre-incident communications can be achieved where messaging: primarily concerns preparedness, sheltering, radiation effects and, if appropriate, stable iodine; details actions that authorities would take in a disaster, including how food would be supplied to affected people; contains a range of actions for varying radiation-disaster situations; is clear in layout and recommended actions; is distributed via multiple methods; shows how recommended actions can be effective, achievable or reasonable; maintains honesty, including stating where there is uncertainty; includes how families can be protected if not together (such as advice around the collection of children from school) and how to communicate with loved ones and, is embedded in institutions such as schools and workplaces. To facilitate increased adherence with protective instructions in the event of a nuclear attack, messages should: provide adequate information (such as how long to shelter) to enable the public to undertake actions; inform the public as to whether food and water could be delivered to those who are sheltering and; use basic terminology.

As catastrophes go, perhaps none are as unthinkable as nuclear attack. And yet, evidence shows that preparedness for such an event is essential. By implementing the measures discussed in this thesis, policy makers charged with communicating pre-nuclear incident preparedness messages to the public may more effectively get their information across.

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Abbreviations

CBRN	Chemical, Biological, Radiological and Nuclear
CDC	Centres for Disease Control and Prevention
FEMA	Federal Emergency Management Agency
GCHQ	Government Communications Headquarters
HI-EMA	Hawai'i Emergency Management Agency
IAEA	International Atomic Energy Agency
IND	improvised nuclear device
KI	Stable Iodine
KT	Kilo tonne
MeSH	Medical Subject Heading
MOD	Ministry of Defence
NPP	nuclear power plant
RDD	radiological dispersal device
TDF	Theoretical Domains Framework
TMI	Three Mile Island
UK	United Kingdom
UN	United Nations
US / USA	United States of America
WHO	World Health Organisation

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Chapter 1: Introduction

1.1. Background

Little Boy, the first atomic bomb to be used against civilians, exploded 1900 feet above Hiroshima at 8.16am on August 6th, 1945. At three-quarters of a mile from the blast residents were thrown off their feet - though many survived. At two miles witnesses had time to react; they sheltered as best they could. Whether due to prior education or instinct, it is likely that sheltering saved lives.

First-hand accounts gathered by John Hersey, later compiled into one book titled *Hiroshima* (1946), documented the event. Hersey's account retains its power to shock readers for its graphic, but still humanistic, descriptions of an event unimaginable in its scale of disaster and suffering. And yet the threat of nuclear war, and the more recent threat of a nuclear device being used by terrorists, continues to hang over us today.

At 08:07 on January 13th, 2018, at the height of a nuclear stand-off between the USA and North Korea, mobile phones in Hawai'i received the message "BALLISTIC MISSILE THREAT INBOUND TO HAWAII. SEEK IMMEDIATE SHELTER. THIS IS NOT A DRILL." Although the message itself was authentic, originating from Hawai'i's Emergency Management Agency (HI-EMA), it had been sent by mistake – no threat had been detected. Subsequent inquiries (e.g. Berman and Fung, 2018; Wang, 2018) into the events surrounding the misuse of the emergency alert system focussed on how such an error could have been made. But one critical factor stood out during the incident – how few members of the public appeared to follow the clear instruction to "seek immediate shelter".

1.1.1. Nuclear risk

Existential risks, such as the deliberate detonation of a nuclear device as a weapon used against the public are termed by Peter Ho from the Centre for Strategic Futures as a black elephant: a product of our cognitive biases to discount future risks whilst placing more weight on present costs and benefits:

> *The black elephant is a cross between a black swan and the elephant in the room. The black elephant is a problem that is actually visible to everyone – the proverbial elephant in the room – but no one wants to deal with it, and so they pretend it is not there. When it blows up as a problem, we all feign surprise and shock, behaving as if it were a black swan (a rare and hard-to-predict event).* (Ho, 2017)

This concept of an obvious yet dismissed or denied risk implies an interaction in cognitive processes in which we implicitly acknowledge that this event may happen but avoid, or pretend that it will not while also considering what preparedness is in place or required. Preparedness here requires not only mastery of protective behaviours, but also the ability to recognise the occurrence of a black elephant and to select the protective behaviours appropriate to this set of circumstances. This ability to select and adapt behaviours in response to difficult or challenging situations is often referred to as agility, or 'the capability to successfully effect, cope with, and/or exploit changes in circumstances' (Alberts, 2014) and should be addressed by risk preparedness communications (the what, when, why and how of a potential disaster). More specifically, this metaphor of a black elephant highlights principles central to effective risk communication: development of protective countermeasures or behaviours; situational awareness (or recognition that the risk exists), and; the ability to choose a response appropriate to the situation (agility).

Agility is a multidimensional concept which encompasses resilience, responsiveness and flexibility, amongst other facets of cognition (Alberts and Hayes, 2007). Importantly, agility is only useful when actions taken are also effective. So, responsiveness is not simply responding quickly, but responding in a timely and efficient manner. In this sense, preparedness requires the ability to anticipate the stages of an event: as a nuclear disaster will almost certainly be dynamic and complex, so to must protective behaviours be dynamic in having to be appropriate for timeline and context. This includes anticipation of the consequences of preparedness and response behaviours. The projected timeline of a nuclear catastrophe is illustrated later in this chapter.

There are around 14,500 nuclear weapons at present, with between 1800 (Ritchie, 2017) and 4000 (Kristensen and Norris, 2017) on 'hard alert': ready to be fired within minutes of notification as an act of aggression or deterrence. Nuclear war is considered more plausible now than any time since the end of the Cold War. In 1947 scientists working on the Manhattan Project used the image of a ticking clock set at seven minutes to midnight on the front of an internal newsletter. Now set yearly by the Bulletin of Atomic Scientists, the Doomsday clock is a representation of how close humanity is to its own demise by nuclear annihilation. Since December 2017 it has been set at two minutes to midnight; the closest since 1953 when the US first tested the H-Bomb (Clay, 2018). Figure 1.1 presents Baum et al.'s 2018 model of nuclear war prediction, which outlines multiple credible scenarios that could result in deliberate events (in red) and inadvertent, or accidental events (in blue) escalation towards the use of nuclear weapons. The shaded area represents historical incidents and the unshaded area is Baum's scenario model.

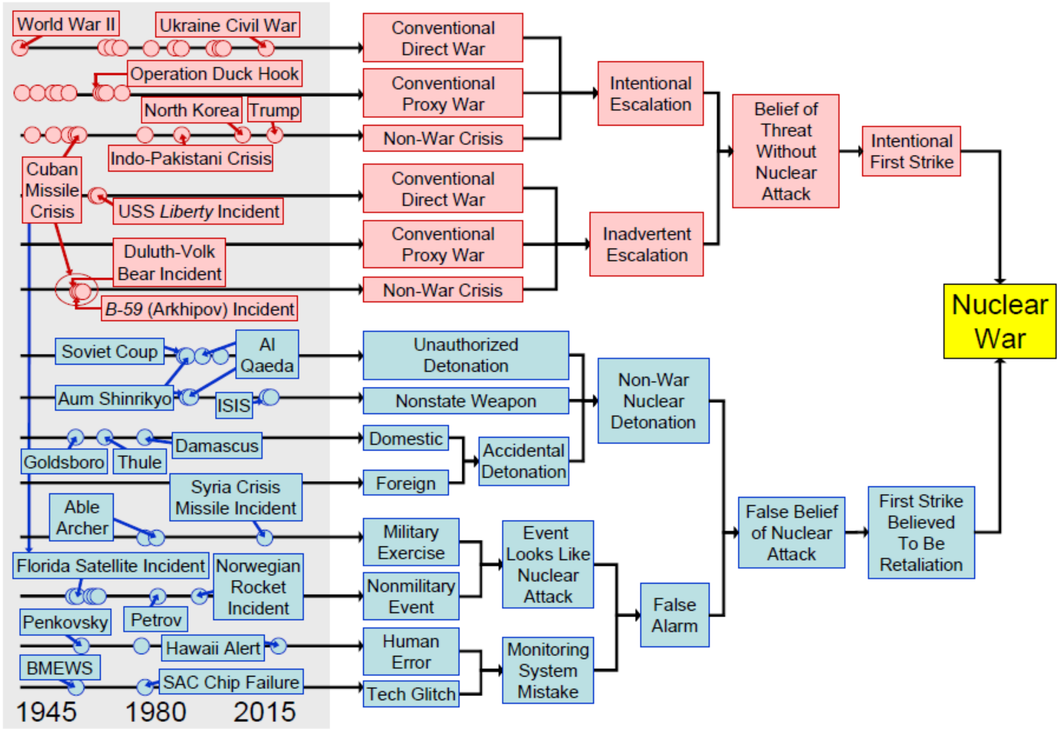


Figure 1.1. A Model for the Probability of Nuclear War (Baum et al., 2018). Reprinted with permission.

Amongst the strategic trends that are causing CBRN threats to evolve, as outlined in an Emerging Risk Report produced by the insurance market Lloyd's (2016) are a growing list of potential perpetrators and advancing technological and scientific capabilities (such as nanotechnology and 3D printing). These advances enable development of cheaper, more powerful and easier to use weapons.

In fact, government studies have concluded that it is plausible for a terrorist group with adequate expertise to make a bomb if they acquired nuclear material. It is easier to make a crude nuclear explosive small enough to fit in the back of a truck than it is to make a reliable weapon of known yield to be delivered by missile or aircraft (Bunn and Roth, 2017). The International Atomic Energy Agency (IAEA) reported 175 cases of nuclear material trafficking between 1993 and 2001 within a worldwide information and equipment sharing network (Becker, 2004). As of 2015 this had increased to 714 cases (IAEA, 2016) with over 100 cases of unauthorised activities involving radioactive materials being reported each year (IAEA, 2013i). Many conflict zones are known sources of nuclear material for occupying and terrorist groups (Shuster, 2017). Al Qaeda has made numerous attempts at acquiring nuclear weapons in

Sudan (1993-1994), Russia (1996) and Pakistan (2001) (Mowatt-Larssen, 2010). Aum Shinrikyo have attempted to purchase and mine their own uranium in Russia and Australia (Daly et al., 2005). As recently as 2014 the so-called Islamic State group made attempts to purchase what transpired to be fictional nuclear material, 'red mercury,' in pursuit of building their own nuclear weapon (Chivers, 2015). The technological ability of states and cyberterrorists to hack into 'Command and Control' defence systems, manipulate early warning systems into believing an attack to be imminent, and force the recipient of the hack into retaliatory action presents an additional risk given the current state of readiness of nuclear weapons (Schlosser, 2014).

Rising tensions amongst worldwide nuclear powers are a likely prompt for governments to reassess their own preparedness measures (Hennigan, 2018). This is particularly true in light of the increased speed at which escalation of conflict between nations can occur (Stafford, 2012). Assessment by experts of the National Academies of Sciences, Engineering and Medicine is that "*the threat picture has changed, and the risk of (nuclear attack) happening has gone up*" for reasons including North Korea's development of nuclear weapons (The National Academies of Sciences, Engineering, and Medicine, 2018). Large and smaller scale nuclear and radiological attacks are also amongst the risks to public health rated highest for potential impact in the UK's most recent National Risk Register of Civil Emergencies (Cabinet Office, 2017i). This register, which comprises expert risk predictions from cross-government agencies, is perhaps the key source document providing direction for the UK planning and response community. Addressing these risks is therefore of vital importance to public health planning and security.

1.2. Nuclear Detonation

Upon detonation of a nuclear weapon, energy is released in three ways, known as prompt effects: a blast wave, powerful enough to topple buildings within a certain radius; heat, likely in the form of a fireball; and a burst of ionising radiation (e.g. Bunn and Roth, 2017). Sources such as the 'Nukemap' website (https://nuclearsecrecy.com/nukemap) and declassified US government data (Glasstone and Dolan, 1977) suggest instant fatality for almost all directly exposed persons within two-thirds of a mile from the blast centre. Estimates of the exact extent of these effects vary depending on the size and type of device detonated (e.g. air-burst or ground-burst). The USA's Federal Emergency Management Agency (FEMA) uses a nominal 10 kiloton (KT) yield (1KT is the measure of energy released by 1000 tons of dynamite (Dodgen et al., 2011)) ground detonated nuclear device to estimate impacts in high-density urban areas in their emergency planning guidance (FEMA, 2010). This size and type of device is agreed by experts at the Lawrence Livermore National Laboratory in the US (e.g. Buddemeier and Dillon, 2009) to be appropriate for preparedness and response planning. Information available in the UK for a comparable device is protectively marked. Throughout this thesis I have followed FEMA's convention.

In contrast to prompt effects, a delayed effect of detonation relates to the dust and debris dispersed by the explosion combining with radionuclides created during the fission process. These attach to air particles which fall back to earth, causing residual radiation. This is commonly called fallout. Health is threatened by gamma and beta radiation emitted in fallout, such as burns to exposed skin. Even up to twenty miles away, unprotected (i.e. unsheltered) people may be killed by residual radiation (FEMA, 2010). Figure 1.2 is a time sequenced example of radiation spread (FEMA, 2010). Whilst a lethal radiation dose would occur within half a mile from detonation, this is perhaps a moot point since people at such a distance would be close enough to be killed by other prompt effects (Wilkinson, 2009). Figure 1.3 presents a comprehensive model of anticipated impacts of nuclear detonation, ranging from thermal radiation (heat) effects, to blast effects, ionising radiation, electromagnetic pulse and subsequent societal consequences of the catastrophe.

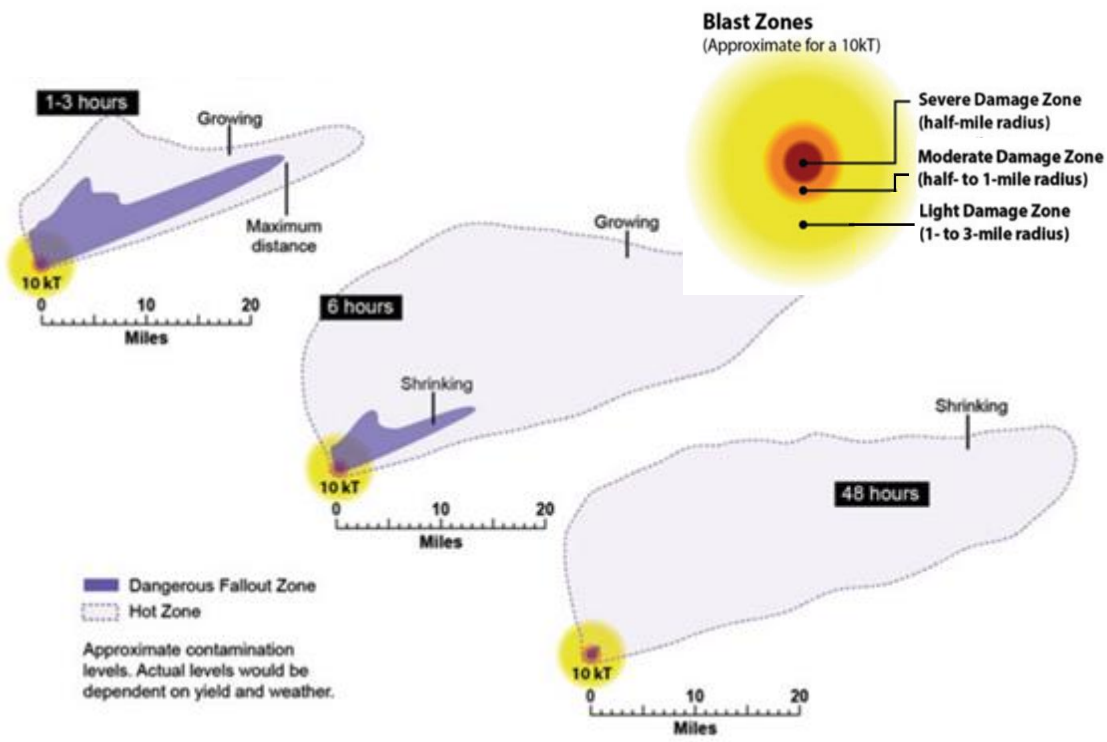


Figure 1.2. Time sequenced size of dangerous fallout zone following a 10KT ground burst (FEMA, 2010). Permission for use requested from https://www.fema.gov/media-library/assets/documents/24879

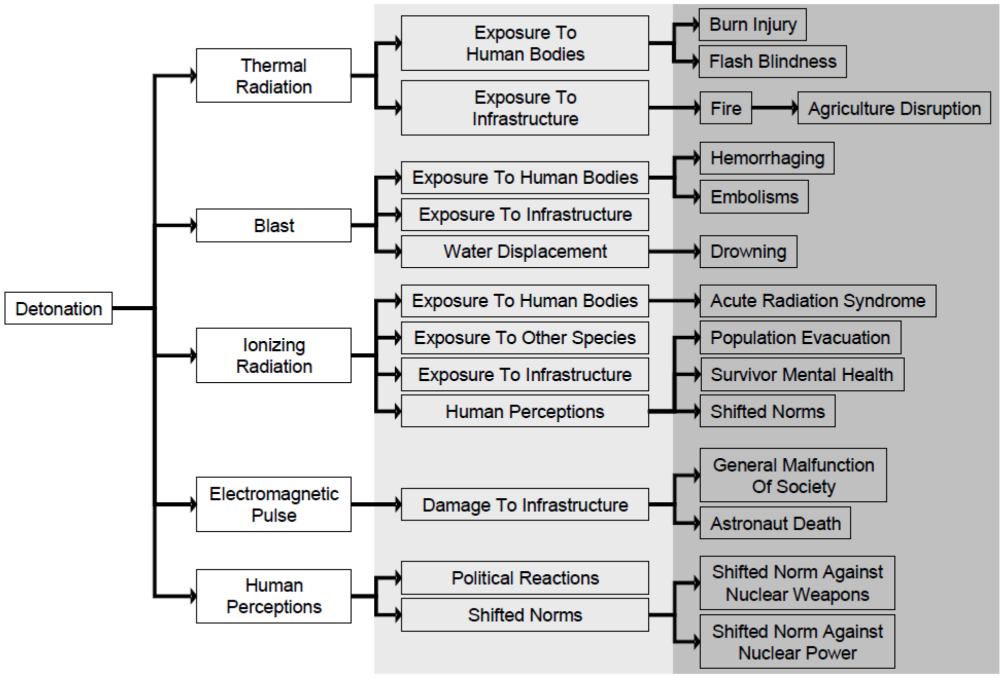


Figure 1.3. Summary of the nuclear war impacts model (Baum and Barrett, 2018). Reprinted with permission.

Baum and Barrett's model shows that nuclear detonation is likely to be catastrophic for reasons in addition to mass fatality. Longer term occurrences such as population displacement (Meit et al., 2011), physical and mental health disorders (Kaidanovsky et al., 2003; Ueda et al., 2016) and the impact of radiation permeating food chains and water sources, not considered in Baum and Barrett's model aside, a number of non-radiation related effects may increase fatalities in the immediate aftermath of detonation. Although modern buildings are not comparable in structure and materials to those destroyed by the atomic bombs used against Hiroshima and Nagasaki, it remains likely that pressure related to wind generated by the blast wave (categorised as dynamic pressure and overpressure) will topple nearby buildings and overturn cars (FEMA, 2010). Beyond three miles physical infrastructure will be largely intact (Hick et al., 2011). An electromagnetic pulse may also cause damage to communication equipment up to approximately three miles distance, though equipment not connected to power outlets such as mobile telephones and battery powered radios are unlikely to be affected (Knebel et al., 2011). Destruction of key infrastructure such as hospitals would severely limit the response abilities of medical services, with any hospitals still functional being compromised in their ability to cope with the thousands of casualties.

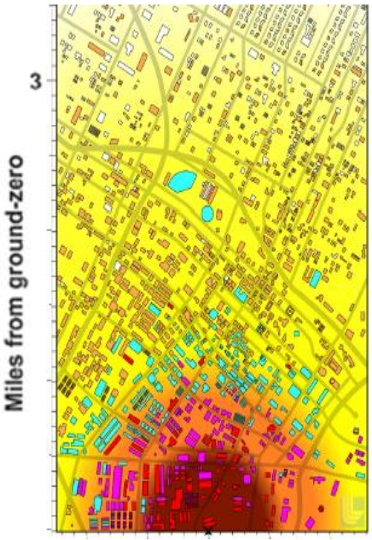
For those with direct sight of the blast, the nearly instantaneous flash of light would be temporarily blinding, possibly causing permanent damage to vision (Buddemeier and Dillon, 2009). However, since light from a detonation moves more quickly than the shockwave it may provide a brief signal (up to 30 seconds if at a mile's distance) to take cover (FEMA, 2010). Unless prepared for such an event, individuals are unlikely to recognise the flash as a nuclear detonation and may be susceptible to injury from breaking glass as they approach windows to investigate (Buddemeier and Dillon, 2009).

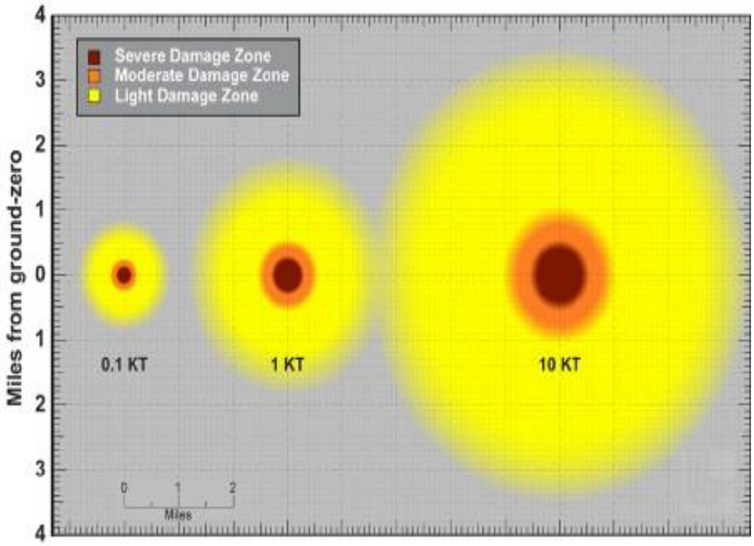
In their 2010 planning response, FEMA propose severe, moderate and light damage zones based upon levels of damage occurring at varying distances. These are presented in Table 1.1. Note that according to FEMA (2016) a 10KT device can cause damage within 3-5 miles of detonation.

Table 1.1. *Emergency planning guidance – Damage zones (FEMA, 2010)*

Severe Damage Zone	Within approx. 0.5 mile radius	Few survivors –protection from stable buildings (underground parking, subway tunnels) may enable survival of initial blast
		Few (if any) buildings left standing
		Radiation levels present significant risk to survivors and responders
		Debris in streets likely impassable
Moderate Damage Zone	0.5 – 1 mile radius	Many people will survive – in comparison to survivors in other zones, these people are suggested to benefit most from urgent medical care
		Substantial building damage (particularly lighter and wood framed buildings)
		Broken water, gas, electrical and communication lines
		Downed utility lines, overturned cars, fires
		Visibility may be limited due to raised dust and smoke
Light Damage Zone	1 – 3 miles radius	Windows and doors will be blown (flying glass injury may occur approx. 3 miles away)
		Vehicles may be stalled or crashed

In the moderate and light damage zones, there is high possibility of injury but survival. However, not only would debris, crashed or overturned vehicles, dust and fire cause major blockages for evacuation and access for emergency responders (Bunn and Roth, 2017), for an initial period of perhaps 24 hours at least, contamination due high radiation levels may also restrict emergency responder access. Whilst radioactivity will rapidly decay (every sevenfold increase in time equates to a tenfold decrease in radiation (Glasstone and Dolan, 1977)) and intensity decreases with distance due to dispersion and absorption by buildings, the risk from exposure to radiation will remain for some time depending on the size of the device (FEMA, 2010). Figures 1.4a and 1.4b are further representations of the range of damage resulting from nuclear detonation. The darker areas indicate the greatest damage and the overall extent of damage lessening in the lighter areas from a 10KT blast in an urban area (1.4a), and in comparison, a 1KT and 0.1KT blast (1.4b).





Figures 1.4a and 1.4b. Extent of damage zones from 10KT nuclear blast (ground burst) (FEMA, 2010). Permission for use requested from https://www.fema.gov/media-library/assets/documents/24879

1.2.1. Nuclear power plant accidents

Nuclear weapons are not the only source of potentially catastrophic radiation release. Nuclear power stations are common in many areas of the world and accidents are far from unheard of.

In a review of intention to evacuate in different disasters, Perry (1983) found participants were unable to distinguish between how radiation might disperse from a nuclear power plant compared to detonation of a nuclear bomb. Particularly, participants typically described outcomes of radiation exposure related only to high doses (e.g. death).

Following the Fukushima nuclear plant disaster in 2011 mandatory evacuation was ordered at up to 20km distance and sheltering at 30km (Moller and Mousseau, 2013). The actual spread of radiation was far greater with the initial radiation plume travelling hundreds of miles (over the Pacific Ocean) in just two days; Fukushima radiation was detected on the west coast of Canada three years later (Buesseler, 2019). Whilst there are no blast effects association with nuclear plant disaster, the potential impact can be widespread, and protective actions similar.

While there may be obvious distinctions between deliberate release of radiation such as via a radiological dispersal device, otherwise known as a 'dirty bomb', or improvised nuclear device and accidental release of radiation such as from a nuclear power plant, these differences become important when considering how the public might protect themselves from the effects of radiation (and associated blast effects in the case of a deliberate release). The Department of Homeland Security (DHS, 2008) provide guidance that outlines these differences. These are presented in Table 1.2.

Table 1.2. *Features of deliberate radiation attack and accidental radiation release (DHS, 2008)*

Deliberate attack (e.g. improvised nuclear device or radiological dispersal device)	**Accidental release (e.g. nuclear power plant accident)**
More likely to occur in a major city centre with large population	Many nuclear facilities are located in less densely populated, rural settings (emergency planning not typically exercised in towns without nuclear facilities)
May start without advance warning	Likely several hours / days of prior warning based on reactor operational characteristics
Radiation release would likely have a relatively short duration	Release would be likely to be drawn out over many hours
If a terrorist act, the incident becomes a crime scene meaning emergency personnel may be further hampered in responding	Most nuclear facilities have detailed emergency plans (e.g. protective actions, evacuation routes and methods to alert the public)
Severity would be dramatically greater than an accident (e.g. a large radius of severe damage)	Evacuations more manageable and impact to critical infrastructure likely to be smaller

In this thesis, I present a series of literature reviews and studies that explore the presentation of risk and preparedness information regarding nuclear risks, with the goal of helping policy makers to develop better methods for informing the public.

But before setting out the specific aims for this thesis, we should first consider the recommended behaviours in more detail. What is it that policy makers want the public to do before or after a nuclear incident has occurred? Why are these behaviours believed to protect against the effects of a nuclear incident? And what previous attempts have been made at engaging the public with information to enhance preparedness for a nuclear incident?

1.3. What can the public do in the immediate aftermath of a nuclear incident?

Before specifying the recommended countermeasures for self-protection in the event of nuclear catastrophe, it is first important to specify where in the timeline of such an event the focus of this thesis sits.

Expressing a timeline for nuclear events comes with several caveats. For example, rising tensions between nuclear powers may present an escalation in risk which presents the general public with great perceived cause for preparedness and engagement with preparedness communications; differing yields in nuclear explosive devices mean that the reach of radiation is less wide in the immediate aftermath allowing for greater time to prepare; similarly, a nuclear device detonation will look different in terms of immediate blast effects coupled with radiation, while a nuclear radiation leak from a power plant may allow for greater time to take countermeasures prior to being effected by the fallout.

The timeline of a nuclear disaster presented in figure 1.5 is therefore an approximation based on key resources in nuclear disaster modelling (these are Buddemeier and Suski, 2015; FEMA, 2010) and actual historical disasters (IAEA, 2011; Nagourney et al., 2018; Pacific Atrocities Education, 2020). Indicated on this timeline is where the current thesis in placed.

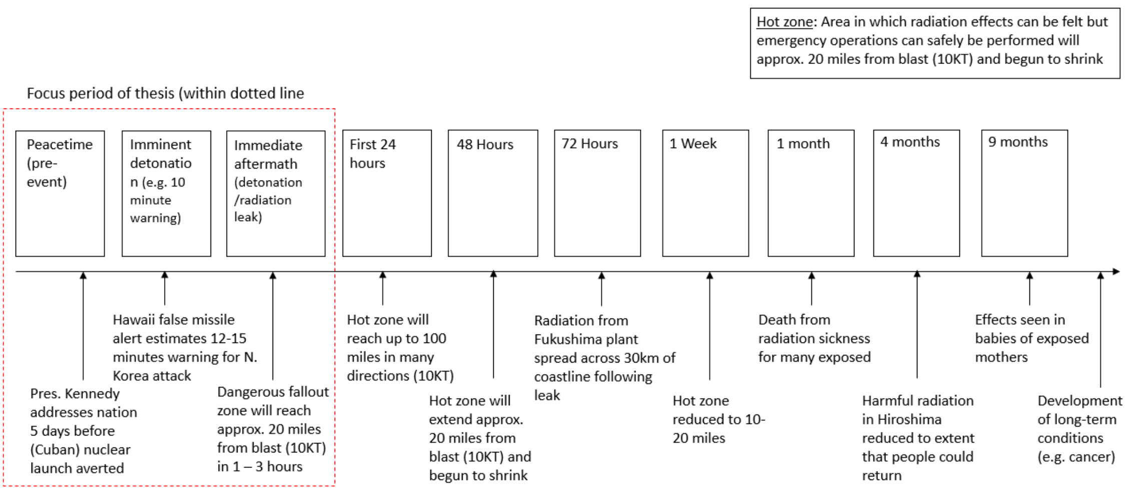


Figure 1.5. Timeline for placement of project within lifespan of nuclear disaster

As this timeline shows, the elongated period post-event would undoubtedly have many far-reaching health effects. Any attempt to cover the full psychological or behavioural aspects of a nuclear incident would take many PhD theses to do justice to, though Redlener and colleagues (2004) suggest a lack of both logistical and emotional preparedness in the public. However, as outlined in this introductory chapter, the actions in the first minutes and hours, as well as prior preparedness can be crucial for survival. In this thesis, therefore I focus on the pre-event and immediate aftermath period of the timeline.

1.3.1. Sheltering-in-place

For survivors of immediate blast effects, at a radius of approximately 0.5 to 1 mile and further, protection from delayed blast effects is largely reliant on ability to shelter, preferably indoors at the nearest location (often referred to as sheltering-in-place) at the time of the blast (DHS, 2008). Whilst considered the action most likely to save lives within the first hour following detonation (FEMA, 2010), sheltering for longer periods will offer greater protection (Buddemeier and Dillon, 2009). This is due to unsheltered people being subject to exposure from gamma radiation deposited on the ground and roofs of buildings: the 'ground shine dose'. The ground shine dose has a typical radiation magnitude greater than internal hazards resulting from inhalation or ingestion. Sheltering-in-place therefore serves a significant life-saving function.

Different shelters offer differing levels of safety. Whilst a basement is considered the optimum shelter (Bunn and Roth, 2017), much contemporary research regarding radiation sheltering is US-centric where, unlike the UK, basements are a more common feature of homes. Buddemeier (2010) suggests that whilst some ionizing radiation can penetrate buildings, shielding provided by walls and moving away from exterior walls (and fallout) will reduce exposure by a factor of 10 or more. Buddemeier defines shelter quality by its 'protection factor': the outside dose rate divided by the inside dose rate. Higher protection factor values mean lower exposure (see Figure 1.6). US federal Planning Guidance for Response to a Nuclear Detonation (FEMA, 2010) considers a protection factor of 10 to offer adequate shelter from radiation fallout.

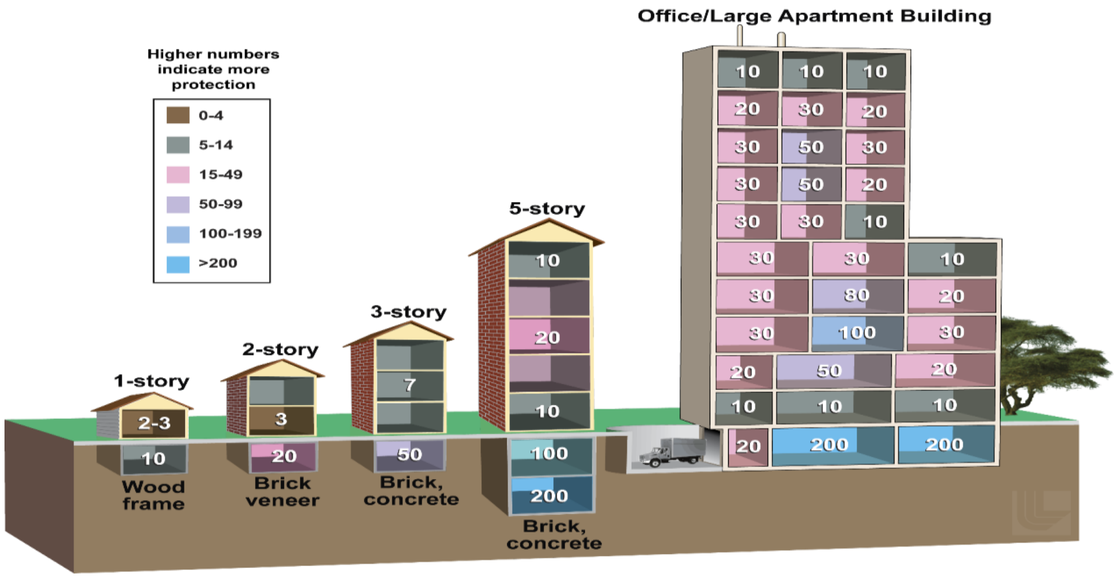


Figure 1.6. Protective factor estimates based on evaluations conducted in the US circa 1960 for typical structures during that era (courtesy of the Lawrence Livermore National Laboratory). Reprinted with permission.

It is notable however that the modelling that was used to provide presumed protective factors was not only based on typical structures for 1960 and are presumably not wholly reflective of modern engineering of city structures, it also simplifies available shelters into three basic types of structure. This is particularly non-reflective of common UK households which are less likely to have a basement, seen here to provide the most effective form of shelter. Presumably, this model does account for sources of potential 'leakage' such as air ducts and water sources, however this is not specified in the source documents. Nonetheless, it does provide a rough illustration of how different forms of sheltering can provide greater or lesser effectiveness in protection from radiation.

A 2010 evaluation of shelter effectiveness by Sandia National Laboratories (Brandt, 2009, as cited in Buddemeier, 2010) named Operation Golden Phoenix used a model developed by the Lawrence Livermore National Laboratory of a terrorist attack near Universal Studios, Hollywood. In this scenario 285,000 people were found to die or be exposed to dangerous radiation levels. Using shelters with protection factor values of 10 reduced this number to 45,000; shelters with higher protection factor values, common in urban environments, would reduce this number still further (Rainey, 2017). Ad hoc mitigation of internal contamination such as holding a cloth over the mouth and nose for respiratory protection in lieu of sheltering is better than no protection at all (FEMA, 2010).

1.3.2. Evacuation

Of course, protective actions still require some notice. Sheltering is potentially feasible for most people who receive an emergency broadcast, such as a ten-minute warning. Evacuation, another protection from radiation (and blast effects) would require more significant warning and planning. Radiation exposure during evacuation depends on evacuation route: without information as to areas of hazard it would be difficult to know which route to take. For miles surrounding the detonation of a nuclear weapon, dust and debris would limit visibility and once settled there would be little visible evidence of fallout affected areas. Further analysis by Sandia National Laboratories showed exposure would be highest for those who shelter for the shortest time and attempt evacuation soonest, as opposed to those sheltering for longer and evacuating many hours or days following detonation (Buddemeier and Dillon, 2009).

Evacuation is perhaps a more effective protection in a nuclear power plant accident if earlier warning is offered.

Protective Action Guides (PAGs; e.g. Environmental Protection Agency, 2017; FEMA, 2016) which detail factors in deciding protective action in nuclear power plant emergencies, based on projected dose to a population, suggests that evacuation is more difficult and costlier as population size increases. However, there is often time in nuclear power plant emergencies for local emergency services to initiate evacuations, particularly if they are able to accurately predict projected radiation plume movement.

1.3.3. Secondary protective actions

'Secondary' protective actions recommended in PAGs include medical countermeasures such as administration of stable iodine (KI). KI works by stopping accumulation of radioactive iodine in the thyroid and is considered most protective in nuclear power plant incidents involving radioiodine release (National Radiological Protection Board, 2001). In the longer term there is potential for consumption of certain foods and water to be restricted if it is believed to be contaminated (FEMA, 2016).

1.4. Preparedness

Preparedness is widely considered to be the most effective way to mitigate disaster impact in general (e.g. Ablah et al., 2009; Katz et al., 2006; Lemyre et al., 2007; Nyaku, et al., 2014; Schoch-Spana, 2013). Taking preparedness actions, such as practising sheltering procedures at work, and receiving risk-communications are associated with an increase in adherence with protective instructions given immediately following radiation release (Dombroski et al., 2006).

Although we cannot say that disaster preparedness alone results in survival without the need for outside assistance (Perman et al., 2011), preparedness actions, such as the storing of non-perishable food and water, are also likely to make sheltering easier should it be required.

Evidence of the public's preparedness for disasters involving radiation is sparse, but we can gain some idea based on research into terrorism preparedness in general. Immediately following the London bombings of 2005, a representative sample of residents of London were surveyed and 51% were found to have made four or more emergency plans (e.g. having a method of contacting family) and 48% had assembled four or more emergency supplies (Page et al., 2008). However, radiation disaster preparedness research conducted with the UK public is mainly concerned with knowledge of preparatory actions for protection in the areas surrounding nuclear power plants. For example, in one survey of residents and workers within 3km of a UK nuclear power plant, only one-in-eight knew what stable iodine was for (Pheby and Robinson, 1990) while only 39% in a separate survey of households in a 550-metre radius of a nuclear submarine testing area knew when to take it (Astbury, 1999).

Similar to the London data, half of New York residents report having compiled emergency supply kits, though they often admit to their kits being incomplete (New York University, 2006). Ablah (2009) found 78% of the public across multiple US states reported feeling prepared for a terror attack but that only 45% had taken at least five of the following actions: evacuation planning, storing three days' worth of water, storing three days' worth of food, storing three days' worth of medications, having a battery-operated radio or having a flashlight and batteries. Murphy and colleagues (2009) found lower rates of preparedness within a similar sample: an average of 0.65 preparedness measures out of four. Eisenman et al. (2006) found that 28% of members of the public in Los Angeles reported having stored emergency supplies following the World Trade Centre and Anthrax attacks of the early 2000s, whilst few preparedness measures were found to have been taken in the Canadian public though many expressed a desire to take first aid training or to assemble an emergency supply kit (Lemyre et al., 2007). Lemyre also found differences in preparedness rates according to factors such as gender, age and education whilst Chesser et al. (2006) found familiarity with preparedness terminology to be less amongst rural focus group participants compared with urban groups.

1.4.1. Recommended preparedness actions

FEMA publishes two-page guidance, most recently in March 2018, titled 'Be Prepared for a Nuclear Explosion' (FEMA, 2018). This guidance elaborates on the 'Get Inside, Stay Inside, Stay Tuned' message. Under the heading 'What to do: Now Prepare' advice includes identification of shelter locations and construction of an emergency supply kit containing bottled water, packaged food, medicine, a battery-powered radio, a flashlight and extra batteries for 24 hours' use (three days if possible). Other documents exist that suggest a greater number of items are required, but for general disaster preparedness (e.g. American Red Cross, 2006; CDC, 2005; DHS, 2006). An expansion of the 'Get Inside, Stay Inside, Stay Tuned' message as detailed on the website Ready.gov (DHS, 2018) is shown in Table 1.3.

Table 1.3. *Full 'Get Inside, Stay Inside, Stay Tuned' message (Ready.gov; DHS, 2018)*

Get Inside	**Stay Inside**	**Stay Tuned**
Get inside the nearest building **to avoid radiation. Brick or concrete are best.**	**Stay inside for 24 hours unless local authorities provide other instructions.**	**Tune into any media available for official information such as when it is safe to exit and where you should go.**
Remove contaminated clothing and wipe off or wash unprotected skin **if you were outside after the fallout arrived.**	**Family should stay where they are inside.** Reunite later to avoid exposure to dangerous radiation.	**Battery operated and hand crank radios will function after a nuclear detonation.**
Go to the basement or middle of the building**. Stay away from the outer walls and roof.**	**Keep your pets inside.**	**Cell phone, text messaging, television, and internet services may be disrupted or unavailable**.

In 2018 Sweden published the document 'If Crisis or War Comes' (Swedish Civil Contingencies Agency, 2018). The brochure, sent to all households in the country at the behest of the Swedish Government, states that "everyone who lives in Sweden shares a collective responsibility for (their) country's security and safety". Whilst not specific to radiation disasters, If Crisis or War Comes provided a checklist of 'home preparedness tips', under the headings: Food (various non-perishable foods that can be stored), Water (store clean jerry cans with water), Warmth (store warm clothes, matches, blankets) and Communications (store a battery powered radio, important phone numbers on paper). It also provides information regarding likely warning siren alerts that might be sounded in emergencies, how and where to shelter and promises that Sweden 'will never give up' if attacked.

1.4.2. What preparedness information is there in the UK?

Preparedness guidance for nuclear attack has not been made available in the public sphere in the UK in modern times (Preston, 2018). Information regarding radiation safety in the event of nuclear power plant leaks ('Go in, Stay in, Tune in' (EDF, 2017)) is primarily distributed to residents within the vicinity of nuclear power plants, and not the wider public.

UK pre-incident disaster communications combine guidance from a number of emergencies. For example, *Preparing for Emergencies* (Updated November 14th, 2018) is published online and as a booklet by HM Government (Cabinet Office, 2018). This guidance, informed by the National Risk Register (Cabinet Office, 2017i) and National Business Resilience Planning Assumptions (Cabinet Office, 2017ii) outlines risks for which communities should plan and prepare. The booklet version (which uses the sub-heading *What you need to know*) contains advice for specific emergencies: fire, bombs and chemical, biological and radiological incidents: no mention is made of nuclear, although it is recognised that the general public are poor at distinguishing between CBRN categories. Due to the catastrophic potential of nuclear hazards, in the event of widespread loss of communications nuclear disaster stands out as a case for which generic C, B or R preparedness information is not adequate.

What *Preparing for Emergencies* (particularly the online version) provides is sign-posting, such as to Local Resilience Forum contact details from which individuals can read about 'planning assumptions' in their local area. Also included are government and emergency response agency steps taken for national security. A key difference between versions of *Preparing for Emergencies* is that the booklet version includes the advice 'Go in, Stay in, Tune in'. The booklet also includes a tear-off page on which emergency contact details and the frequency at which the local radio station can be written.

1.5. Nuclear preparedness in the UK

There was a time during which nuclear safety was a more public concern in the UK. To provide warning of an imminent attack during the Cold War period (1947-1991) some World War Two sirens were retained to provide a 'four-minute warning'. A national warning message authorised for distribution using the code word *Falsetto* was also recorded by Peter Donaldson (a 'familiar voice,' intended to reassure the public that the BBC had not been wiped out). It instructed the public via radio to "stay tuned to this wavelength, stay calm and stay in your own homes". It also gave instructions to turn off gas supplies, how to ration food and to fill containers with water (Davey, 2018). Again, this was reliant upon factors such as people being able to tune in and being aware of the need to do so. It is unclear whether arrangements such as this are currently in place.

Perhaps more widely recalled is a pre-nuclear incident information campaign prepared for the Home Office by the Central Office of Information (COI) and distributed in 1980 called 'Protect and Survive' (HMSO, 1980). Protect and Survive was distributed to the UK public in the form of a booklet, 20 televised films, 22 radio scripts and a series of newspaper inserts. The originally planned broadcast schedule involved distribution during low level crisis (TV and radio only), during a 'preparatory' period (booklet only) and via all mediums if an attack was thought to be probable. The booklet version of Protect and Survive bills itself as "tell(ing) you how to make your home and family as safe as possible under nuclear attack", whilst it goes on to note the uncertainty that would come with nuclear war, it does suggest that those living in rural areas are potentially in equal danger to those living in towns which are perhaps perceived to be more conventional targets. In bold letters, Protect and Survive declares that readers should take note of its contents: "Your life and the lives of your family may depend upon it". Specific advice includes planning a fallout room with inner refuge to be used for shelter in the event. Pictures show a man moving large furniture in front of floor-to-ceiling glass doors, blocking the fireplace and chimney with bags and bricking up windows. It also details the items that should make up a survival kit including drinking water, tinned food, portable radio and spare batteries, tin and bottle openers, cutlery and crockery and warm clothing. Preparations for sheltering include keeping a portable stove and fuel, table and chairs, first aid kit, boxes of sand, brushes and shovels, cleaning materials, a clock and a calendar. It also advises on how to construct a make-shift toilet. Following an attack, people are advised to remain in their shelters or point of refuge for up to 48 hours without going outside until instructed that it is safe to do so.

Although not the only nuclear preparedness example of public pedagogy (public education for political purposes) to be distributed since World War Two, Protect and Survive is remembered as the most controversial. It was received poorly upon distribution and considered a 'fantasy document' (Preston, 2014) in many quarters. Amongst criticisms levelled at the publication, the preparedness and protective actions presented were considered unrealistic and too simplistic in the face of such a complex and uncertain event. A 1982 BBC documentary (QED: A Guide to Armageddon) had people follow the guidance included, concluding it to be lacking in efficacy. It was criticised for commercialisation and promotion of DIY as protective measures such as building a fallout shelter (Stafford, 2012). The reliance on resources to carry out a number of these actions caused ideological criticism, with accusations that it was classist and racist due to the potential for inequalities in patterns of survival across socio-economic groups (Preston, 2014). Protect and Survive was also alleged to promote the idea of nuclear war as survivable: a way for the Government to get the public to support their stance on nuclear weapons. This, it was suggested, represented a misplaced effort wherein the Government should be focussed on prevention. Production of Protect and Survive was considered an admission that the government had failed in this (Preston, 2014).

Protect and Survive came at a time of severely limited public spending on civil defence. According to the then Permanent Secretary at the Home Office, Sir Philip Green, the primary concern at that time was to provide warning to the public in the event of nuclear attack (Stafford, 2012), an approach not fitting the definition of civil defence. Subsequently, the campaign was developed from restricted information. For example, the video series includes a clip entitled 'stay at home' intended to dissuade the public from mass evacuation, warning that "nobody can tell where the safest place will be" and stating that by moving the authorities will be unable to assist with food and other essentials (HMSO, 1980). This new 'stay at home' policy was withheld from a parliamentary statement reporting conclusions of a Home Defence Review of 1970–1, subsequently used as a basis for civil defence funding allocation. Ultimately, The Home Office appeared to favour simplicity in their presentation over the information given by advisors. Selective inclusion of information in Protect and Survive was felt to be dictated by a need to weigh public adherence with necessity for national survival (Stafford, 2012).

This public backlash, coupled with government disagreements regarding distribution (Preston, 2017) has meant that no follow up to Protect and Survive has been produced. The COI produced "Civil Defence – Why We Need It" (COI, 1981) to address questions that arose following the publication of Protect and Survive. Still, in 1985 the COI brought together public survey findings that around 40% in the UK believed nuclear war to be 'likely someday' but that around 80% expressed pessimism about their chances of survival, considering civil defence to make little or no difference to this (Preston, 2014). The COI also found the public to desire an honest approach from the Government regarding defence from nuclear war. This perhaps is at odds with previous communication campaigns such as Protect and Survive in which there is an emphasis on documents being politically defensible with practical use in an emergency being a secondary concern. Protect and Survive was considered didactic in its approach, fitting more with early behavioural science concepts of a panic-stricken public rather than contemporary models of a rational and aware public (Preston, 2014).

1.5.1. Other attempts to change behaviour

Other previous attempts at providing effective preparedness communications to the public reveal the many challenges for such campaigns.

As with Protect and Survive, the original US civil defence campaign, 'Duck and Cover', is considered misleading by many in the public for the popular perception that it suggested nuclear war to be survivable. However nuclear defence experts consider much of its protective recommendations to be constructive and worth resurrecting (Sander, 2018). According to nuclear weapon historian Alex Wellerstein (Reinventing Civil Defence, 2017), at least in the US, "Cold War perceptions are unfortunately the ones that guide a lot of our discussions about civil defense(sp) and nuclear preparedness today". Whilst such protections may be largely ineffective in the face of thermonuclear weapon bombardment, they would certainly prove effective for many in scenarios involving detonation of smaller devices: radiological dispersal devices; a 10KT improvised nuclear device perhaps used by a terrorist group; in the event of a nuclear power plant leak; or even in detonation of a single larger device such as those developed by foreign nuclear powers.

Previous studies have shown public mistrust of preparedness advice to be reinforced by distribution of unclear information (Kuroda, 2017) or not meeting public expectations (Frewer et al., 1996) presenting barriers to engagement. This is a problem since adherence (Bass et al., 2015) and preparedness (Eisenman et al., 2012) are reduced where there is low trust in the officials' providing information. Mistrust of information also affects information processing, such as reducing capacity to integrate large amounts of information or make complex decisions (Keselman et al., 2005). The nuclear industry has been found to be significantly less trustworthy in public opinion than local authorities and scientists (Latré et al., 2017). Further to this, attempts at influencing preparedness and increasing knowledge of protective behaviours in the context of civil defence in the UK has received equally negative publicity (Preston, 2014) as Duck and Cover in the US, or has not been engaged with or recalled when needed (Page et al., 2008; Rubin et al., 2005). In fact, one evaluation of emergency preparedness literature distributed in the US found behaviour change (engaging in at least one preparedness action) in only 10% of the population (Marshall et al., 2007).

According to Rachel Bronson in the Bulletin of Atomic Scientists, there is less concern regarding nuclear threat in young people today due to a rise in personal threats such as gun violence and because many did not live through the era of Duck and Cover. Bronson states that "images (of this time) do not resonate in the same way (with people today). We need to approach it differently". In the UK in the 1980s 40% to 50% of respondents to nationwide polls reported fear of nuclear war to be a serious issue for them. After the Cold War this dropped to 1-2% (Clay, 2018).

During the 1980s there was some push back against the idea of nuclear planning, causing the distribution of Protect and Survive to have the opposite than desired effect in some cases. This was reinforced culturally such as by the release of the BBC film Threads (Hines and Jackson, 1984) which depicted the aftermath of a nuclear attack on Sheffield. To many, Protect and Survive and Threads highlighted the absolute horror that nuclear attack would bring and the perceived "absurdity" (David Blunkett, leader of Sheffield Council between 1980-1987; Clay, 2018) of trying to protect oneself. Actions in Protect and Survive were considered by many either not doable (e.g. keeping bottled water at a time when bottled water was not a common feature of everyday life) or not effective (e.g. papering over windows). Some UK cities declared themselves nuclear free zones during this time, meaning nuclear preparedness was not considered (Clay, 2018).

Lofstedt (2003) suggests that individuals make decisions about risk initially based on factual information, and on emotion (based on previous experiences) only in lieu of facts. This is particularly the case when inconsistency occurs, such as when messages do not reflect risk for everybody in the same way (e.g. not reflecting economic status: Bass, 2016). This may be a contribution to the failure of Protect and Survive. For example, in assessing information seeking and interpretation of radiation risk, focus groups made up of school principals in Estonia with no prior knowledge of a risk to draw upon had difficulty making sense of a nuclear power plant leak warning. Basing their responses on emotional content then led to disagreements and uncertainty (Harro-Loit et al., 2012).

This presents a substantial issue. In the event of any disaster involving radiation, be it nuclear detonation, radiation leak or radiological dispersion device, sheltering-in-place is likely to be the most life-preserving action that the public can take (e.g. Becker, 2004; Buddemeier and Dillon, 2009; FEMA, 2018). However, members of the public are often either unaware of this fact or consider advice to shelter to be an outdated remnant of the Cold War (Redlener, 2018). What is more, available evidence on the provision of public education materials for preparedness and protective actions to take in incidents involving any chemical, biological, radiological and nuclear (CBRN) agent suggests that the provision of education material is not always enough to alter the public's behaviour (Florig and Fischhoff, 2007; Heagele, 2018). People may not engage with the material prior to an incident, may become overly anxious

(Taylor et al., 2011) or may not remember the information when they need it (Hildebrand & Bleetman, 2007). Education material may be particularly ineffective if the likelihood of an incident occurring is perceived as being low (Rogers et al., 2013) and if suggested actions to take are perceived as ineffective (Taylor et al., 2011).

There is therefore a need to identify facilitators and barriers to engagement with pre-incident information, and to examine ways to overcome potential barriers. This should enable more effective pre-incident messages about nuclear terrorism to be designed that are likely to enhance public engagement and therefore promote public preparedness for nuclear catastrophe.

1.5.2. Need for improved public communication around radiation emergencies

Previously, the US National Council on Radiation Protection and Measurements (NCRP, 2001), emphasized social, psychological, behavioural and communication issues as key to the success or failure of preparedness and response efforts for radiation emergencies. According to the NCRP, a communication approach to preparedness should be "*informed by an awareness of people's fear and concerns and that effectively conveys the information needed to protect health and safety*". Not attending to psychosocial and communication issues could result in increased morbidity and mortality and inability of responding organisations to maintain public trust. The Centres for Disease Control and Prevention (CDC), reflecting on the overwhelming volume of requests for information during the 2001 anthrax attacks, concluded that the risk of unconventional terror attacks necessitated a proactive approach to risk communication that involved the use of basic, agent-specific messages distributed pre-event (e.g. Becker 2004).

In reviewing responses to nuclear and radiological emergencies, including the Fukushima nuclear power plant catastrophe, the IAEA found public communication to be amongst the biggest challenges in radiation emergency management (IAEA, 2013ii; Tateno and Yokoyama, 2013).

Increasingly, development of strategies for effective communication are recommended at all phases of a crisis, including the preparedness stage (Seeger, 2006). Yet despite these and other endorsements of pre-event communication, public communication around nuclear risks has rarely focussed on preparedness. In part, this is due to a belief that preparedness recommendations will not be accepted by the public and in part it relates to fear that confidence in civil nuclear activities might be harmed (e.g. Oshita, 2017).

Practical difficulties in communicating about nuclear risks also exist. A review by Prezelj and colleagues (2016) found practical limitations to communicating in the event to include: difficulty coordinating messages in unpredictable and complex emergencies; different opinions and perspectives adding to difficulties in coordinating information about risk situations and; difficulty (or impossibility) of effective public communication without public involvement in pre-planning.

These findings highlight the scientific uncertainty, evolving situations and the pressure that responding organisations will be under to provide timely, clear, and consistent information in a radiation emergency such as ways in which survivors can protect themselves and their families (Freimuth, 2006). Having some understanding of what is known by the public regarding an emergency of this nature can allow communicators to ensure their message resonates with pre-existing knowledge (Glik, 2007). Nonetheless, protective messages delivered when detonation is imminent or immediately following detonation would have to provide detailed information and instructions, with little time for the public to act, and in a period of incredibly high stress. Development of effective pre-incident communications which are distributed during ‘peacetime’ can complement what information could be given to the public in the event of an incident.

1.6. Theoretical approaches to radiation risk communication

Whilst there are practical steps that can be taken to reduce the risk of harm should a nuclear catastrophe occur, people will only take these steps if aware of them. Informing the public of protective actions falls within the remit of risk and crisis communication.

1.6.1. Risk and crisis communication

In disaster communications literature, the terms *risk communication* and *crisis communication* are often used interchangeably (e.g. Covello, 2003; Latré et al., 2017; Wendling et al., 2013; Wray et al., 2006). However, *risk communication* can be defined as specific to communicating about adverse outcomes and the probability of that outcome occurring, either informing decision making in the future or helping recipients in adjusting to the knowledge of outcomes of an event that happened in the past. *Crisis communication* concerns presenting of factual information such as actions the public should take in the event of an unexpected disaster. In this definition the information presented is assumed to be sound and not requiring an expert to validate its truthfulness. *Emergency risk communication*, according to this definition, combines the requirement of communicating risks and benefits with the urgency of a crisis, by means, according to Glik (2007), of practices and requirements less generic than those involved in standard risk communication. The term risk communication will be used from this point to indicate communications incorporating aspects outlined in the definitions of both *risk* and *crisis* communication above.

Risk communication has been used to improve public understanding of CBRN risks (Etchegary et al., 2008), to inform the public, manage fear and fatalism, encourage cooperation with protective instructions given by authorities during a crisis (National Research Council, 1989) and enhance openness in science-policy making (House of Lords Committee on Science and Technology, 2000).

Covello (2011) considers risk communication to be effective in emergencies if providing timely, accurate, clear, objective, consistent and complete information; it can “rally support, calm a nervous public, reduce misinformation, build trust and confidence in the public towards responding authorities, encourage cooperative behaviors(sp), and potentially help save lives”. For risk communicators it has been suggested that effective messaging requires more than simply knowledge of the risk, but should empower the audience, provide an honest and empathic exchange and adopt cultural and demographic requirements such as language, education and communication styles (Aherne, 2010; Fischhoff, 1995; Ulmer et al., 2007).

Non-crisis, or *pre-incident* risk communications are designed to share content that has meaning attributed to it by the message recipient (Windahl et al., 2009); recipients being the population whose “behaviour, attitudes or knowledge is to be influenced, directly or indirectly’” (Glik, 2007). In its broadest sense, pre-incident communication should meet the requirements of the recipient who receives the information; understands the information; understands that the message applies to them; understands that they are at risk if they do not take the recommended protective action(s); decide that they need to act on the information; understands what action(s) need(s) to be taken; and is able to take action (Mileti and Sorensen, 1990).

Whereas emergency risk communication can result in misinformation or inconsistency (Pew, 2006; Rainie, 2005) by combining unexpectedness, threat, stressed populations and a mass media that is looking for news (Garrett, 2001) particularly during the immediate period (Thelwall & Stuart, 2007), pre-incident communication can be undertaken in a more measured way, giving time and consideration to what is said, when it is said, who says it and to whom it is said (Covello and Anderson, 1988).

The design of pre-incident communications, according to Florig and Fischhoff (2007), deserves detailed analyses not only to provide the public with sound advice, but also to ensure that authorities disseminating messages have realistic expectations of the public's response to them. Certainly, studies have shown that the public perceive CBRN terrorism as being low in likelihood and consider preparedness planning for such events to not be worthwhile (e.g. Lemyre et al., 2007) though severity of consequences is rated differently in terms of societal consequences, as opposed to personal impact (Lemyre et al., 2006; Krewski et al., 2005). Pre-incident communication should also support the public in making decisions, and not just provide facts (Lasker, 2004). Messages that have undergone empirical evaluation give the public the greatest chance of understanding the risks they face and of making appropriate choices (Florig and Fischhoff, 2007).

Examples exist of radiation specific-messaging designed with public information needs in mind. For example, the CDC sponsored Pre-Event Message Development Project (e.g. Becker, 2005) was designed to improve public messaging for (amongst other things) nuclear terror events. The methodology used in this large-scale project placed the public and their self-reported information preferences at its heart. Similarly, The Rhode Island Department of Health used a social marketing approach (rather than a more traditional top-down planning approach: Brown, 2006) to identify pre-emergency ''wants and needs'' of the public. Following a series of focus groups and interviews a pre-intervention awareness flyer and 32-page informational booklet (*Make a Kit, Make a Plan, Stay Informed*) was produced (Marshall et al., 2007).

1.6.1.1. Risk communications to increase preparedness

Preparedness, or at least knowledge of what protective actions to take in the event of nuclear incident, is likely to save lives. One central illustration of the life-saving function of preparedness is that areas close to nuclear detonation will be devastated, with communications and access for emergency services limited. Assistance may not be possible for many hours, if not longer (DHS, 2008). Being prepared to shelter-in-place for prolonged periods by storing emergency supplies such as food, water and essential medication can help maintain safety during this early period following detonation (Department of Energy and Climate Change, 2015; FEMA, 2018; Wray et al., 2008). Key preparedness actions are explained in further detail below (section 1.5.1. Recommended Preparedness Actions). Whilst we cannot, individually or as a community, expect to be fully prepared for a catastrophic nuclear attack, distribution of effective pre-incident preparedness communications should help reduce fatalities. For example, a central message in contemporary UK radiation protection guidance developed by the independent National Steering Committee on Warning and Informing the

Public is to ‘Go in, Stay in, Tune in’ (e.g. EDF, 2017). This mnemonic (and U.S. guidance to ‘Get Inside, Stay Inside, Stay Tuned’ (FEMA, 2018)) advises waiting for further information from emergency officials once sheltering. However, in the event of a nuclear attack it is not certain that communications will be open for this purpose, or for how long they might be down. And given that it is assumed that “no significant response” would be available (perhaps optimistically) for at least 24 hours (Bunn and Roth, 2017), ensuring the public are prepared for lengthy sheltering, and have knowledge of how to protect themselves in such a situation is probably wise.

It is widely considered that pre-incident risk communication for radiation emergencies requires a focus on presenting the information that people most need to understand but have yet to learn (Fischhoff et al., 2003). Yet simply providing factual information may not be enough to engage those who are sceptical about the need to take action such as preparedness measures (e.g. Rubin et al., 2015). Members of the public might be frightened or anxious at the time of receiving information; communications must be sensitive to this. Ensuring provision of credible and relevant information can enable action and adherence in an anxious and frightened, but informed public (Timmons, 2010). For this reason, it is vital to provide scientific rigor to the process of developing effective and evidence-based risk communication (Rubin et al., 2015).

This is equally relevant for policy makers in creating realistic policies wherein authorities charged with civil defence and emergency response would benefit from understanding, “how people think about, perceive and respond to risk” (Ho, 2013). Without this understanding such policies may be ineffective. Current UK communication directives tend to focus on statutory requirements to include particular information (such as technical specifications) rather than basing public communication on evidence of what information people want or need. For example, nuclear safety information leaflets distributed to those living close to nuclear sites are designed to satisfy the Health and Safety Executive (HSE) Radiation Emergency Preparedness and Public Information Regulations (REPPIR) (HSE, 2018) requirements, but these do not provide guidance on how best to present the information (Hellier et al., 2014).

1.6.2. Theoretical perspectives: Behaviour change models in disaster research

If communication is key to increasing preparedness, how should this communication be performed? With its genesis in environmental risk, disaster management, health promotion and media communications, current risk communication research draws upon social, cognitive and economic psychology and their applications within organisations and the community (Glik, 2007). Whilst there are undoubtedly aspects in the many theories of risk communication that are relevant to this project, such as the use of heuristics, or rules-of-thumb, in the reception of information (Chaiken, 1980), the use of persuasion through positive or negative associations (Petty and Cacioppo, 1986) or the interpretation of risk shaped by information processes, institutional structures and interpersonal interactions (or 'social amplification', Kasperson et al., 1988), there are many characteristics of these theories that do not necessarily apply to the research questions.

The models outlined here have historically been used in understanding and development of risk communication messaging. They share aspects including risk perception, knowledge and perceived trust in the communicating source. Alongside the goal of increasing knowledge, risk communications are intended to influence behaviour. This emphasises the importance of using models of behaviour change to guide practice it is not enough to simply increase knowledge, the public must be motivated to act on information. In this section, I will summarise several key theories that I believe can add to our understanding of how best to communicate radiation risk to the public.

Learning Theory

Learning theory suggests that establishment of knowledge networks (or mental maps) assist in organising information as people learn about their world (Keselman et al., 2005). Knowledge acquired from new information must resonate with what is already known (in accordance with personality, experience and cultural influence) before assimilation into working memory (Kools et al., 2004). This suggests that risk communications must account for knowledge already acquired and beliefs held about the type of disaster being targeted to effectively frame the information presented. The use of Learning Theory as a basis for the development of radiation risk communication is supported by many radiation disaster and communication study outcomes. For example, information campaigns for residents near nuclear power plants (Železnik and Perko, 2012) and informational videos (Latré et al., 2017) can increase radiation knowledge and reduce risk perception, leading to greater acceptance of subsequent messaging during non-crisis periods (Perko et al., 2012; 2013). Whilst a number of academics (e.g. Khripunov, 2010; Kiisel and Vihalemm, 2014) echo the view that the public tend to base their views of risk on personal experience, one challenge in this area is that few people have had experiences that can provide meaningful guidance in reacting to nuclear attack. The public tend to demonstrate low levels of knowledge about CBRN agents in general and hold inaccurate beliefs about them which can make communicating about CBRN incidents particularly challenging (Fischhoff et al., 2003).

Social-Cognitive Model

Whilst it is not a model of communication per se, the Social-Cognitive Model of individual response to terrorism (Lee and Lemyre, 2009) with its genesis in Social-Cognitive Theory (e.g. Bandura, 2001) draws upon the concept that intentions to take preparatory actions, motivated by outcome expectancies and self-efficacy, are dependent on social-contextual factors such as trust in the source of preparedness information. Whilst providing information about terrorism has been found to alter perceptions as to the probability of terror-events occurring (Lerner et al., 2003), the Social-Cognitive Model posits that affective responses (such as worry) are a function of such cognitive evaluations, in addition to social-contextual factors. These factors, most centrally perceived coping-efficacy, perceived likelihood and perceived front-line preparedness, are predictors of individual preparedness and information seeking behaviour. Testing of this model has suggested that raising awareness about both individual ability to survive terror-related disasters and front-line preparedness may reduce worry and subsequently encourage individual preparedness.

Figure 1.7 is a full representation of the cognitive, social-contextual and affective factors that the model proposes to influence behavioural response to terror. This model is supported by research with the public regarding a deliberate radiation release which highlight barriers to information engagement including perceived low likelihood of an incident occurring (Rogers et al., 2013), and the suggested actions being deemed ineffective (Taylor et al., 2011). Not only is this an issue in terms of public communication but a challenge also exists in convincing policy-makers to pay attention, and perhaps even allocate funds, to a catastrophe that may not even happen (Ho, 2017).

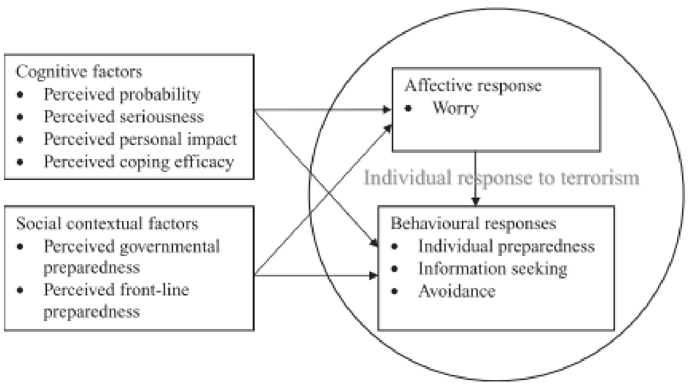


Figure 1.7. Model specifying relationships between cognitive factors, social-contextual factors, affective response and behavioural responses to terrorism (Lee and Lemyre, 2009). Reprinted with permission.

The social-cognitive model may also account for unhelpful behaviours occurring in response to radiation emergencies. For example, one survey of intended responses in a hypothetical radiation scenario found that misperceptions regarding likelihood and methods of exposure are associated with increased worry and engaging in behaviours detrimental to the response effort such as attending monitoring and assessment facilities unnecessarily (Pearce et al., 2013).

Communication Persuasion Matrix

Covello (2011) suggests risk communication is based on four organising models which affect how information is processed and how perceptions of risks are formed. These are the *risk perception model* in which risks are perceived differently if upsetting or believed to have potential to cause harm; the *mental noise model* which explains the degree to which stress and strong emotions impair information processing; the *negative-dominance model* which suggests negative information is given greater weight (loss aversion) and is attuned to more than positive information, and; the *trust determination model* which places trust as the central aspect in determining perceptions of risk. This is an elaboration of the Communication Persuasion Matrix (McGuire, 1989), also known as the 'input-output' matrix. This matrix comprises five input variables: *source, message, channel, audience and destination (desired outcome)* that relate to the characteristics of the communication itself and can be manipulated to elicit a set of 13 possible outputs. The output is concerned with how the audience processes information. Each output variable (or 'stage') must occur for communications to be considered effective in changing behaviour.

Outcomes of studies into radiation emergency response and risk communication support Covello's organisational model of communication. For example, warnings alone have been found not to motivate protective behaviour and instruction adherence; individuals must also perceive risk (Lee & Lemyre, 2009). Yet radiation concerns causing the public to feel they need to be prepared may not necessarily prompt protective actions. For example, 81% of respondents to one US survey considered the threat of a dirty bomb attack on their country to be serious; however, 63% considered themselves unprepared for an attack with 56% uncertain of how to respond (report to the Radiological Threat Awareness Coalition, 2008).

Often it is perception of risk and not the actual risk itself that influences response (Fischhoff et al., 2003). This reinforces the need for scientific information to be presented in ways that non-technical audiences can understand; with faulty risk perceptions causing misunderstanding and misinterpretation of scientific or probabilistic information (Slovic, 1987). Addressing counterproductive perceptions and beliefs in the public represents a further challenge in the development of effective preparedness communications which might be addressed using models such as the Communication Persuasion Matrix.

Extended Parallel Process Model

The Extended Parallel Process Model (EPPM: Witte, 1992; Witte & Allen, 2000) suggests that under some circumstances (such as when perceiving low self-efficacy) fear-inducing messages can provoke resistance (including avoidance, denial and reactance). The Theory of Psychological Reactance (reactance is "the motivational state that is hypothesized to occur when a freedom is eliminated or threatened" (Brehm & Brehm, 1981) and has been found to weaken the impact of health messages that invoke fear (Witte, 1992)) and EPPM are perhaps applicable to the apparent existence of a pervasive sense of fatalism in public attitudes regarding radiation. For example, the nuclear attack survival rate expected by the public was quantified in one study (Nasar & Greenberg, 1984) to be lower than 50% despite a belief that survival chances were enhanced by evacuation planning. In another study (Malešič et al., 2015) respondents felt nuclear sites are safe, but qualified this by stating that in a radiation leak there would be no time to employ protective actions if instructed. This belief in almost certain death in a radiation emergency of any nature may be a powerful barrier to engagement in risk communications that suggest otherwise. Though EPPM is not focussed solely on reactance and fatalism, these are aspects relevant to this topic.

The social psychology of public response to warnings

According to Mileti, perceptions are formed in response to emergency warnings in the same way that perceptions are formed in any other social event (e.g. Mileti and Peek, 2000). Such processes are affected by beliefs, understanding, experience-based expectations and environmental cues, such as the behaviour of others (Sorenson, 1983). This model is used to explain behavioural responses to emergency risk communications, and not to pre-incident risk communication.

Mileti suggests this process involves sequential stages. Mileti and Peek (2000) present these in the context of radiation emergency risk communications. The first stage is hearing: warnings or sirens may not be heard by all. The second stage is understanding: not simply ability to interpret, but also the attachment of meaning; understanding therefore includes risk perception. Third is belief: for example, the perceived accuracy of information. The fourth stage is personalisation of risk: the perceived implications that the risk may have on the receiver. The fifth stage is deciding how to respond, and the final stage is performing the behaviour.

These sequential stages are repeated each time new information is received and so, risk is perceived as an emerging process, not resulting from a single event. This is additionally impacted by the content of warnings, the style of communication and recipient characteristics. Rather than await the delivery of information, however, people actively seek additional information (warning confirmation: Mileti et al., 1975).

Summary

A common feature of these models is that interruption of perceptual, cognitive and behavioural steps during engagement with and assimilation of information, such as by questioning of the validity of the message, is a cause for non-adherence to risk communication (Tierney, 2000). This may be particularly the case when considering radiation emergency preparedness wherein the effectiveness of communications may be reduced by the nature of their *high-risk, high-outrage* qualities (Sandman, 1989). For example, emotions such as fear that are likely to reduce information processing in a major event (Nutbeam, 2000).

Below I will outline how models of behaviour change are applied in a disaster context.

1.6.2.1. Models of health behaviour change in disaster research

Health behaviour research has examined how the public can be helped to make positive behaviour changes at an individual level such as smoking cessation (Black et al., 2020) or vaccination uptake (Smith et al., 2020).

There are a number of behaviour change models central to health-promotion research and application. For example, Social Cognitive Theory (e.g. Bandura, 2001) suggests that the public learn socially contextual information through continual interaction with their environment and has been applied in public health communication (e.g. Breastfeeding of pre-term babies: Ahmed, 2009; AIDS prevention: Bandura, 1994). In 2006, NICE (Taylor et al., 2006) published a comprehensive review of social cognition theory based models, namely the Health Belief Model (HBM; Rosenstock et al., 1994), the Theory of Reasoned Action (TRA; e.g. Fishbein and Azjen, 1975), the Theory of Planned Behaviour (TPB; Azjen, 1985) and the Trans-Theoretical Model (TTM; Prochaska & DiClemente, 1993) and use of each in predicting health related behaviour change.

The reviewers found none of these models were able to incorporate the significance of social, economic or environmental factors as determinants of health behaviour. They went on to suggest that a priority for promotion of effective public health research is to integrate and extend the existing capacities of established models. While evidence such as NICE guidelines suggest that we are moving closer to establishing models of behaviour with proven success in supporting health behaviour change, the evidence as to the effectiveness of behaviour change approaches remains unclear (Laverack, 2017). A further issue in the use of behaviour change in health promotion is in its widening of health inequality (e.g. Baum, 2007). According to Laverack (2017) a comprehensive strategy (that includes a behaviour change approach; a strong policy framework and the empowerment of people to take control over health decisions) will require both behaviour change communication opportunities and community empowerment.

Models of behaviour change traditionally used in health psychology are increasingly applied in disaster research. Paton (2003) identifies intention-formation variables including outcome expectancy and self-efficacy in disaster preparedness attitudes amongst the public. Using the Social-Cognitive model to inform motivation towards disaster preparedness, Paton suggests that after thinking about the hazard itself, the public would then make judgements as to how their actions might mitigate those hazards. Paton also suggests that variables such as a sense of belonging to their community moderated the extent as to which preparedness intentions translated into actions.

Recently we have seen the importance of applied health psychology in the early 2020 SARS-CoV-2 (Covid-19) pandemic. Without a vaccine available at the time of the outbreak, slowing it's spread requires nation and even worldwide behaviour change. Raihani and de-Wit (2020) found that people who reported more concern also adopted more preventive behaviours while concern for the self and family predicted behaviour change and support for policy change. A key countermeasure in the quest to protection from coronavirus is self-isolation, or quarantine. Webster and colleagues (2020) identified factors associated with quarantine adherence during infectious disease outbreaks finding adherence decisions were related to perceived knowledge about the disease and quarantine procedure, perceived risk and perceived benefits of quarantine.

However, there is a need for consideration of the use health behaviour models in public health communication and disaster preparedness research. In a systematic review of the application of behaviour change theories in emergency health preparedness, Ejeta and colleagues (2015) found that theories and models of health psychology have been applied predominately to disease outbreaks and natural hazards with little information as to their use in man-made disasters.

Whilst many theories of what influences behaviour can be brought to bear on the current problem, in recent years, constructs found to be influential in behaviour change have been subsumed into the Theoretical Domains Framework (TDF; Cane et al., 2012).

1.6.3. The Theoretical Domains Framework approach

The Theoretical Domains Framework is a holistic model for behavioural change theory. This framework integrates constructs present in 33 models of behaviour change to include a range of mental and social processes and contains 14 domains with 84 component constructs (Table 1.4). For example, the domain *knowledge* comprises the constructs: knowledge of scientific rationale (e.g. knowing the evidence for recommended actions is sound), procedural knowledge (e.g. knowing the actions to take if advised to shelter-in-place) and knowledge of task environment (e.g. knowing the place in which sheltering is necessary, including the resources to do so effectively within it).

Table 1.4. *Key domains relating to behaviour change in the Theoretical Domains Framework (refined)* (Cane et al., 2012)

Domain (definition)	Example Constructs
Knowledge (awareness of existence of something)	Knowledge of condition/scientific rationale; procedural knowledge
Skills (ability or proficiency acquired through practice)	Skills development; competence; ability
Social / professional role identity (individual's behaviours / personal qualities in social or work setting)	Social identity; group identity
Beliefs about capabilities (acceptance of ability that can be put to constructive use)	Perceived competence; self-efficacy; empowerment; beliefs
Optimism (confidence in desired outcomes being attained)	Optimism; pessimism
Beliefs about consequences (acceptance of outcome of behaviour in a given situation)	Outcome expectancies; attitudes; beliefs
Reinforcement (increased probability of outcome by arranging a dependent relationship between response and given stimulus)	Rewards (proximal/distal, valued/not valued, probable/improbable); incentives; contingencies
Intentions (conscious decision to perform a behaviour in a certain way)	Goals (autonomous, controlled); intrinsic motivation
Goals (mental representations of desired outcomes)	Goals (distal/proximal, autonomous/controlled); action planning
Memory, attention and decision processes (retaining information, selectively focussing and choosing between alternatives)	Cognitive overload/tiredness; attention control; decision making
Environmental context and resources (circumstances encouraging or discouraging skill development)	Environmental stressors; resources; barriers and facilitators; person x environment interaction
Social influences (interpersonal processes that change thoughts, feelings or behaviours)	Social and group pressure/norms/supports
Emotions (experiential, behavioural and physiological elements used to deal with personally significant events)	Anxiety; fear; stress
Behavioural regulation (managing or changing observed or measured actions)	Self-monitoring; breaking habit; action planning; direct experience

The TDF represents a new science of behaviour change designed as an integrative model (which includes the behaviour change wheel) that allows mobilisation of knowledge for policy makers, making science actionable. It is a particularly good model to support research into public reactions to information about nuclear incidents, since it is designed to bring together the range of social, environmental and psychological processes which make up its domains. Bringing together conventional but disparate models avoids the potential constraints of these models in identifying areas for targeted behaviour change. To apply the TDF to behaviour change implementation, an understanding of the nature of behaviour in its specific context is required. It can be used to inform the Capacity, Opportunity and Motivation – Behaviour (COM-B; Michie et al., 2011) model, commonly used to answer the question of what needs to change in order for a desired behaviour to occur. The COM-B suggests that behaviour occurs as an interaction between three conditions: capability to enact behaviour, motivation to enact or inhibit a behaviour and opportunity within an enabling environment. For example, physical and psychological capability may map to physical skills and knowledge possessed by the individual. It is a dual process model; the COM-B recognises behaviour change resulting from automatic (implicit and unconscious thought) and reflective (explicit, controlled and conscious thought) processes. According to this model, the automatic system is a stronger influence on behaviour than the reflective system.

By identifying a desired target behaviour and gathering information that addresses TDF domains (Michie et al., 2005) in the necessary context, behaviour change interventions can be designed. In this case, evidence-based communications can be designed that target psychological processes most likely to change behaviour such as those which present a barrier to engagement or instruction adherence.

This model proposes ways in which we can use research methods to understand how to design behaviour change interventions. One such way is through a process of systematic review of the literature, qualitative research to gather a rich understanding of how the problem is conceptualised in the public sphere, and quantitative data collection to refine the ideas arising from the previous phases. Basing these approaches on the TDF helps to ensure that potentially important components are not overlooked.

1.7. Towards a model of nuclear disaster preparedness communication and behaviour

Communications are recommended at every phase of disaster preparedness and response, however, as is outlined in the literature I have detailed above, when the public are provided with pre-incident information, they have more time to prepare, potentially allowing for a greater impact. This literature also shows particular psychological factors that are at play in making communications effective. Fatalism and trust in the communicating source, for example are shown to be important in risk-related behaviour response, risk perception and uncertainty are shown to be important in multiple studies, with mixed findings as to the role of anxiety (e.g. Gray and Ropeik, 2002; US Dept of Health and Human Services, 2002). The evidence of the role of self-efficacy and perceived likelihood are scant in the literature, despite good theoretical arguments for the importance of these factors. A model is presented below (figure 1.8) which outlines factors (including societal, psychological, communications) for consideration in the development of effective nuclear disaster communications at each phase. This conceptual model is intended to represent specific factors that might be of influence on behaviour that are identified in the literature, and broader factors that may be expected to be relevant based on theory.

This model is an attempt to illustrate the current thinking as to how behaviour might be changed through effective communication by integration of the concepts that have been introduced within this introductory chapter. It is not my intention to test all factors within this model. Instead, those that are most relevant or most amendable to study in the context of a PhD will be explored, and the model updated in the final chapter.

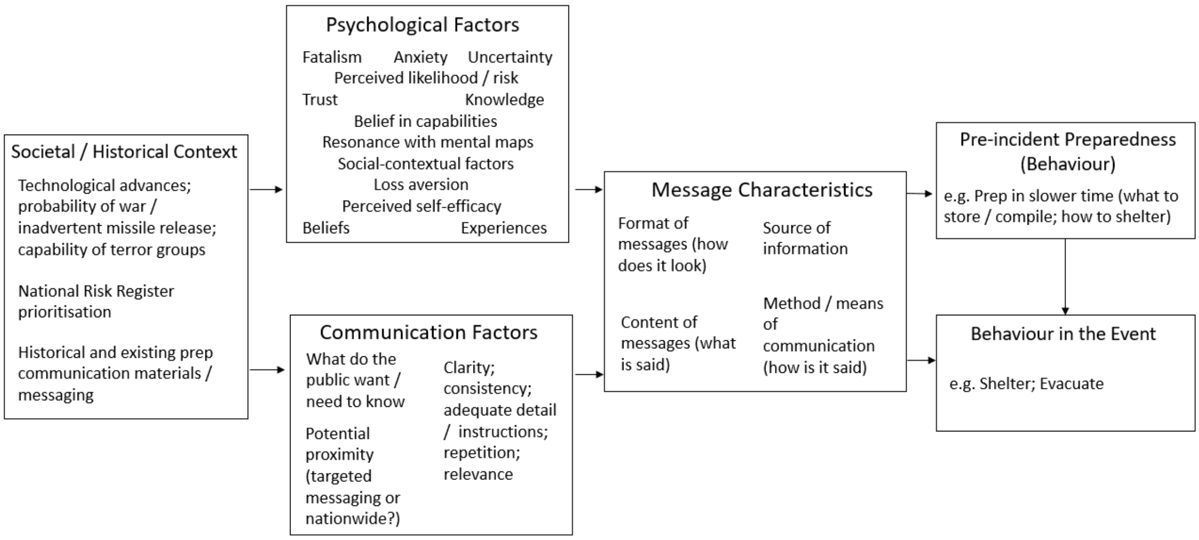


Figure 1.8. Model representation of factors known to contribute to effective communications targeted at behaviour change. This includes social and psychological factors that derive from the literature outlined above and some derived from the following models: Theoretical Domains Theory; Learning Theory; Social-Cognitive Model; Communication Persuasion Matrix; EPPM; Social Psychology of Warning Response.

1.8. Project aims

A prepared public is important to reduce the risks associated with nuclear incidents, yet the public are underprepared and research on how best to remedy this is scant. The theories I have reviewed suggest various key features that may be important. These include framing of information being communicated in alignment with perceptions and cognitions to ensure the public are able to carry out desired behaviours, and considering social-contextual factors that are meaningful to the public such as trust in the information source, perception of the risk involved and the provision of sufficient information.

This, in turn, can be achieved by three steps: ensuring that pre-incident communications inform the public of what they *want* to know in the event of a radiation emergency to enhance engagement in those messages; ensuring that pre-incident communications inform the public of what they *need* to know in the event of a radiation emergency to reduce barriers to engagement such as fatalism and lack of trust in the source of the message and; ensuring the message is framed in a theoretically and evidence-based way to maximise the likelihood of behaviour change.

I have outlined a framework (model) of factors that come into play in this context. My overarching aim for this thesis is to identify preparedness behaviours and how best to communicate with the public about preparedness for an incident involving the release of nuclear radiation. Several sub-objectives are used to achieve this. As this is an applied thesis in which I am producing work intended to inform policy, as opposed to generating theory, my desired goal for this work is to generate policy recommendations.

The specific aims of this project were therefore to:

1. Identify predictors of behaviour in a. preparation for and b. the immediate aftermath of an incident involving release of nuclear radiation.

In line with the specific potential barriers and facilitators to engagement with pre-incident communications outlined in this introductory chapter, variables tested included trust, anxiety, fatalism, recall of protective actions to take in the event, perceived risk, pre-existing knowledge, perceived efficacy of suggested countermeasures, perceived self-efficacy, situational and personal factors such as being a parent and perceptions of frontline preparedness.

2. Identify how best to communicate pre-incident information to the public.

Specific aspects of risk communication to be tested include: whether communications are most desired pre-incident or during the incident; who do people want to receive messages from; what format is preferred; what content should be included; and what method of distribution is preferred?

These aims were met through four phases of data collection, reported in the following four chapters. In Chapter 2, I describe a systematic review of studies that have previously explored predictors of preparedness, adherence with recommended countermeasures and pre-incident information seeking for nuclear disasters. I note here that the nature of the event in question, that of catastrophic radiation release has thankfully, seldom occurred in history, and so study of communication around this phenomenon is reliant on both hypothetical and real scenario outcomes. While this might be an issue in terms of drawing conclusions, this approach does allow for the documenting of various aspects of the preparedness problem.

Objectives of this review relating to aim 1 are to identify:

1. factors which are associated with behaviour in preparation for a nuclear incident, including whether the public will attend to pre-incident messages;

2. factors which are associated with behaviour in the immediate aftermath of a nuclear incident.

The objective of this review relating to aim 2 is to identify:

3. preferences among members of the public for information designed to educate them about actions to take in the event of a nuclear incident.

In Chapter 3, I report the results of focus groups with members of the general public that explored pre-nuclear disaster information preferences.

The objective of this study relating to aim 1 is to identify:

1. possible predictors of behaviour in the preparedness and immediate stages of a nuclear emergency.

Objectives of this study relating to aim 2 are to identify:

2. what factors might promote engagement with pre-nuclear incident communications;

3. the preferred pre-incident information distribution method among the public;

4. factors that promote trust in the message and perceived source credibility.

In Chapter 4, I report on an online survey of the Hawai'i public conducted to explore their immediate behavioural responses to the false missile alert of January 2018 as well as prior preparedness behaviour, and the factors associated with these behaviours.

Objectives of this survey relating to aim 1 are to:

1. identify the proportion of people who a) possess adequate materials (as defined by HI-EMA) within their home to allow them to cope with a nuclear emergency, and b) possess these materials specifically as a result of attempts to prepare for a nuclear emergency;

2. assess adherence to the instruction to shelter-in-place. This will be achieved via the following sub-objectives:

a. identify the prevalence of behaviours that were, a) deliberately adherent to the instruction to shelter, i.e. involving participants taking active steps to follow the guidance; and b) incidentally adherent, i.e. involving participants taking active steps to follow the guidance or else being adherent by virtue of circumstance, such as being in bed at the time;

b. identify the proportion of people who believed the message to constitute a genuine emergency alert;

c. assess whether the following variables were associated with adherence and preparedness outcome variables: by what means the message was received; whether participants believed it to have been a genuine message from HI-EMA; whether they believed an attack to be imminent; whether they had prepared for an emergency; how much preparedness information they had previously received; their level of trust in Hawai'i's defence capabilities; their perceived likelihood of a nuclear attack occurring in Hawai'i, and; the perceived level of effort involved in taking protective measures (such as sheltering).

The objective of this survey relating to aim 2 is to:

3. assess the desire for pre-incident information relating to nuclear preparedness following the false alert.

Aligning with the second of the project aims, the same survey was used to gather additional data that would be of use in developing improved communications with the population, specifically: ways in which participants attempted to find out information as to how they could protect themselves or others; from which sources they had obtained preparedness information prior to receiving the warning; how recently had this information been received; whether this information was viewed as having been sufficient; preferred timing of communications; reasons for not wishing to receive pre-incident communications; preferred content of pre-incident communications, and; their ratings of trust in potential information sources.

Finally, in Chapter 5, I report an online survey of the UK public which studied factors that facilitate nuclear attack preparedness and engagement with pre-incident communications.

Objectives of this survey relating to aim 1 are to:

1. identify the proportion of people who a) possess adequate materials to allow them to cope with a nuclear disaster, b) possess these materials specifically due to a concern about nuclear disasters and c) are prepared out of a concern for general emergencies;

2. assess whether the following variables were associated with disaster preparedness: perceived risk to self and loved ones of a nuclear attack against the UK (and perceived likelihood of an attack occurring and it not affecting them); perceived risk to self and loved ones of an unspecified disaster in the UK (and perceived likelihood of a disaster occurring and it not affecting them); how much preparedness information they had previously received; perceived information sufficiency; their level of faith in the UK's defence capabilities; the perceived level of effort involved in taking preparedness measures (such as storing items) and effectiveness in sheltering, as is recommended in nuclear disaster preparedness guidance, and; demographic variables.

The objective of this survey relating to aim 2 is to:

3. identify factors that promote anticipated engagement with pre-nuclear incident communications, including: timing (whether during peacetime or when a threat is known/raised); source of the communications; method and format by which communications arrive (i.e. online or leaflet; from government official, nuclear expert or other), and; perceived risk perception of a nuclear disaster occurring during their own lifetime, and the risk of this having a direct impact upon themselves or their loved ones.

As can be seen, there was a broad initial scope to this thesis in which both nuclear and radiological radiation disasters were to be examined in the context of pre-incident preparedness. This is reflected in the scope of my systematic review. But, as data were generated, the aim of this thesis was tightened to be focussed on the specific issue of nuclear attack scenarios. The reasons for this are primarily an identified lack of previous literature regarding public perceptions of nuclear attack preparedness and response behaviour, PPI group feedback prior to undertaking focus groups (which minimised the discussion of an accidental radiation release scenario) and finally the false ballistic missile alert in Hawaii which occurred during the course of my studies and which became the focus of my first survey.

Chapter 2: A systematic review of factors associated with behaviour in relation to a nuclear incident, and reported preferences for information

2.1. Introduction

As we have seen in Chapter 1, recent advances in the capability and willingness of terrorists and state actors to use unconventional weapons (NATO, 2015) have raised the spectre of catastrophic attacks against civilian populations. The potential for chemical, biological, radiological and nuclear (CBRN) weapons to generate large numbers of casualties, economic harm and widespread fear unfortunately acts as an incentive (Mazzone, 2013; NATO, 2015) and reports exist of terrorist groups trying to acquire radiological capability (Shuster, 2017) and operating weapon development facilities (Meulenbelt and Nieuwenhuizen, 2015).

Radiological and nuclear incidents are perhaps the most alarming to the public and emergency planners alike. Catastrophic terrorist attacks, including use of a nuclear device, were identified as amongst the highest priority risks in the 2015 UK National Risk Register (Cabinet Office, 2015) and as having the highest impact severity in the 2017 edition, with civil emergencies such as nuclear power plant leaks also figuring highly (Cabinet Office, 2017i).

If such events happen, public reactions will play a substantial role in determining eventual mortality rates (Khripunov, 2015). In one model of a nuclear detonation in Los Angeles, the potential number exposed to harmful radiation fell from 285,000 to 45,000 when people sheltered in even moderately protective buildings (Buddemeier, 2010). Immediate evacuation following release of radioactive material can result in increased exposure as well as hindering the ability of emergency responders to attend the scene (Sugimoto et al., 2012). Other behaviours, such as moving quickly away from windows following the flash of a detonation (Buddemeier and Dillon, 2009), assembling an emergency supply kit ahead of time (Ablah et al., 2009; Taylor et al., 2011) and (for those near a nuclear power plant) taking stable iodine tablets in the event of a release (Khripunov, 2015) are also likely to reduce mortality rates. However, planners have often assumed that panic and lack of knowledge will prevent the public from following instructions on how to protect themselves (Preston, 2014). Furthermore, belief about CBRN lethality (Sheppard et al., 2006), unfamiliarity (Covello, 2011) and unpredictability (Smith, 2010) have been found to elicit intense responses in the public such as anxiety (Becker, 2004) and fatalism (Taylor et al., 2011). In smaller radiological incidents, misperceptions, for example of the routes of radiation exposure, are associated with increased worry and engaging in potentially harmful behaviours (Pearce et al., 2013), and overburdening of medical facilities (Havenaar et al., 2003).

Generic advice has been written about how to communicate health emergency risks with the public. Recent guidelines emphasise, among other things, the need to consider social and cultural influences on risk perception (WHO, 2017), the importance of understanding personal risk exposure (Rubin et al., 2011) and media relations training for emergency responders (Glik, 2007). Yet, whether the public are likely to engage in specific protective behaviours during situations likely to create fear is unknown.

In Chapter 1, I discussed the benefits of using the Theoretical Domains Framework to help improve the development of pre-incident communications. Atkins et al. (2017) and Chadborn and Sallis (2019) outline the practical applications of the TDF, suggesting that relevant contributors to the behaviour that is targeted for change should be identified and ranked for frequency at which it arises in the literature. This allows us to identify domains for inclusion in further investigation and for consideration in the design of an intervention.

In this chapter I present a systematic review of studies which have assessed public responses before or immediately after a radiation disaster to identify factors that should be addressed in a future communications campaign, categorised according to the TDF. The objectives of this review were to identify:

1. (aligning with the first of the project aims) factors which are associated with behaviour in preparation for a nuclear incident, including whether the public will attend to pre-incident messages;

2. (aligning with the first of the project aims) factors which are associated with behaviour in the immediate aftermath of a nuclear incident;

3. (aligning with the second of the project aims) preferences among members of the public for information designed to educate them about actions to take in the event of a nuclear incident.

2.2. Method

2.2.1. Study identification

I searched Ovid (Embase; Medline), PsycINFO (NICE HDAS), Web of Science and the Emergency Planning College online library (http://epc.cirqahosting.com/HeritageScripts/Hapi.dll/search1) from inception to January 2017. Keywords and MeSH terms were grouped into three categories: nuclear terms and events (e.g. *radiation*, *Chernobyl*), radiological terms and events (e.g. *dirty bomb*, *Litvinenko*) and behavioural or communication terms (e.g. *shelter*, *evac*; communicat**). The full strategy is in Appendix A. Searches were conducted up to 31st May

2017. Titles and abstracts were downloaded using Endnote software. I undertook a detailed review of the full text of papers plausibly meeting the inclusion criteria. A sub-sample of papers were crossed checked with project supervisors.

2.2.2. Inclusion criteria

I used five inclusion criteria. First, only studies which sampled the public were included. I excluded studies if the population sampled had received occupational training in emergency response procedures.

Second, I included studies relating to actual or hypothetical incidents involving a radiation hazard in which the potential for physical harm was present.

Third, I included studies if they explored factors associated with behavioural response before a radiation incident occurred and/or in the immediate aftermath. Studies were also included if they assessed preferences relating to pre-event or post-event information provision. ;

Fourth, I included studies if they used self-report (such as questionnaire or interview) or objective methods (such as footfall data) to assess actual or intended behaviour. For information preferences, I included outcomes measured through self-report, objective indices or any related measure.

Fifth, due to resource constraints, I only included papers published in English.

2.2.3. Data extraction

Where possible, I extracted data from each study regarding design, type of incident, location, sample, what predictors or correlates of behaviour were studied and outcome assessment.

2.2.4. Risk of bias

I appraised the quality of included studies using Downs and Black's (1998) checklist (Deeks et al., 2003; Pettigrew and Roberts, 2006). This has been validated for assessment of both randomised and observational studies. Items assess reporting, external validity, internal validity and confounding. Items not relevant to studies included in this review were not assessed (e.g. blinding). Studies were given a score out of twenty-two with a high score equating to high quality (see Appendix B, Table B1).

2.2.5. Procedure

I conducted the literature search, application of inclusion criteria, data extraction and quality appraisal with the project supervisory team providing consistency checks of a subset of results.

I grouped studies according to the predictors of behaviour that were assessed. Further subdivisions were based on whether incidents were nuclear or radiological, actual or hypothetical, and whether the study used a quantitative or qualitative approach. Differences in outcomes between studies relating to accidental nuclear facility emergencies and deliberate detonation of nuclear or radiological devices are explicitly mentioned in the results where these were apparent.

For quantitative studies I extracted effect sizes where possible and used a narrative approach to their synthesis. I used meta-ethnography to synthesise qualitative studies (Noblitt and Hare, 1988). This involves induction and interpretation of original data across a seven-step process allowing for building of a 'comparative understanding' (Barnett-Page and Thomas, 2009). Steps of this systematic approach to synthesis involve coding and mapping, or extracting characteristics of included studies to provide a 'map' of the research on this issue (as defined by the review question and inclusion criteria). This iterative process allowed for identification of the clearest categories within which outcomes are reported and headings are generated. Integration of findings allows creation of higher level explanations of phenomena. This approach was chosen as it allowed me to take into account the heterogeneity of included studies.

In accordance with the TDF approach, factors that were associated with behaviour related to information seeking, preparedness and adherence (including acceptance of pre-incident communications) were categorised under one of the 14 domains of the framework. Each factor was ranked by frequency at which each was identified in the literature as being key to behavioural response to, and messaging preferences for a radiation emergency. Tables for each domain (with examples for each construct) are presented in Appendix C.

2.2.6. Prospero registration

This review was registered with Prospero on 20/01/2017 and was added to the Prospero database on 23/01/2017. Registration number: CRD42017055664.

2.3. Results

2.3.1. Search results

I identified 9480 records by database searching. Following de-duplication, another 155 were identified from forward-citation and reference list searching of included papers, an index of behavioural science publications held at Public Health England and the Emergency Planning College library. See Figure 2.1.

Outcomes from four studies were reported across multiple papers (Kanda et al., 2013i; Kanda et al., 2013ii; Kanda et al., 2013iii; Perko et al., 2012; Perko et al., 2014; Perry, 1981; Perry, 1983; Prince-Embury, 1991; Prince-Embury, 1992i; Prince-Embury, 1992ii). Therefore, while the total number of papers included was 41, the total number of studies included was 35.

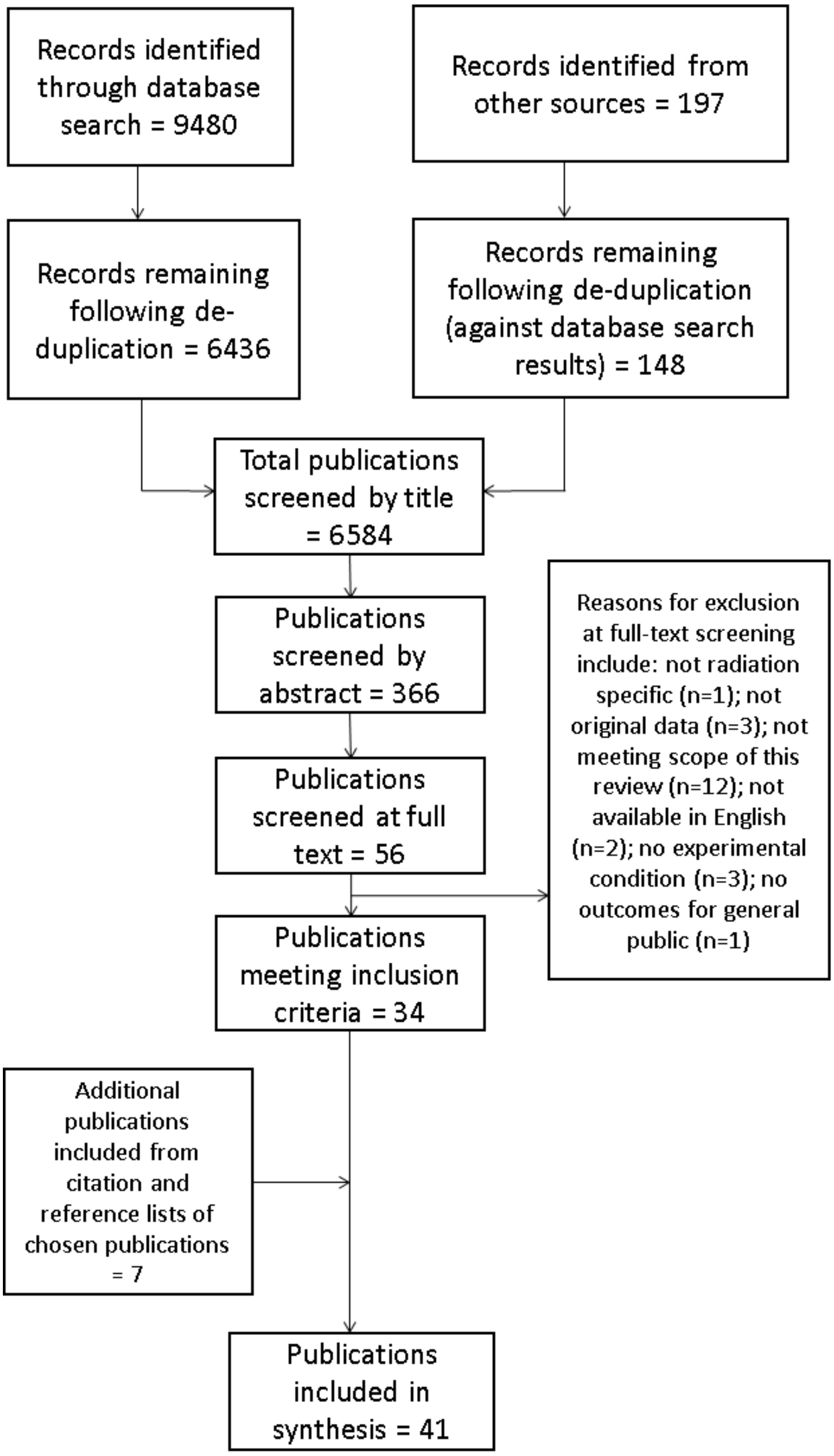


Figure 2.1. PRISMA flow diagram of study selection. Reprinted with permission.

2.3.2. Study characteristics

Thirty-three papers reported outcomes of quantitative methods, three used qualitative methods, three used a mixed methods approach and two employed an experimental design. Twenty-one studies (producing 24 papers) were undertaken with US or Canadian populations and 10 (producing 11 papers) with European populations. Of the remaining studies three were conducted in Japan and Australia (producing six papers).

Nineteen articles (based on 14 studies) presented data on behavioural responses to real emergencies (including the Fukushima and Three Mile Island leaks) or events such as mass distribution of iodine prophylaxis, while 22 concerned hypothetical situations. Tables 2.1-2.3 provide a summary of the methods for each study (studies are listed in the table as according to whether they used a hypothetical scenario or materials, or whether they reported findings from an actual event or used materials in public use at the time of the study).

Table 2.1. *Methodologies for studies involving nuclear agents (Survey designs)*

Ref	Study Design	Participant demographics (if listed)	Inclusion criteria	Variables measured	Event / location
Studies involving hypothetical scenarios					
Bass et al., 2016ii	Survey (face-to-face)	N=50; 58% female; ages 18-88	Low literacy adults recruited from local community	Predictors of adherence with sheltering instructions	Hypothetical RDD scenario / US
Becker, 2004	Secondary survey data: Marist College Institute for Public Opinion: government threat protection; Pew Internet and American Life Project	Not reported	None specified	Information seeking (preferred source, during incident); Perceived source credibility; Predictors of adherence with sheltering instructions	Hypothetical small IND / US
Carini, 2011	Survey (unspecified) (71% response rate)	N=353; 45% females; ages <25 to >70	Local area agricultural group members	Information seeking (preferred source, during incident); Perceived source credibility	No scenario used / Italy
Gerber et al., 2006	Survey (telephone)	N=800 (83% white ethnicity; 66% employed; 66% married)	Residents within states surrounding Washington DC	Perceived source credibility; Predictors of adherence with sheltering instructions; Predictors of adherence with evacuation instructions	Hypothetical nuclear detonation / US
Guterbock et al., 2010	Survey (telephone)	N=2657	Residents of national capital region (Virginia, Maryland, Pennsylvania, West Virginia, Delaware, Columbia District)	Information seeking (preferred source, -pre-incident); Information seeking (preferred source, during incident); Perceived source credibility; Predictors of adherence with sheltering instructions; Predictors of preparedness behaviour	Hypothetical RDD scenario / US
Latré et al., 2018	Survey (face-to-face)	N=1031; 51% female; ages: 18 to 55		Perceived source credibility	Simulated TV news segment(s) / Belgium
Lee & Lemyre, 2009	Survey (telephone) (9·70% response rate)	N=1502; 51% female		Predictors of preparedness behaviour; Predictors of information seeking; Predictors of avoidance behaviour	CBRN terrorism / Canada
Lemyre et al., 2007	Survey (telephone) (9·70% response rate)	N=1502; 51% female		Information seeking (preferred source, pre-incident)	No scenario used / Canada
Malešič et al., 2015	Survey (unspecified) (50% response rate)	N=502	Residents within 3km of Krško NPP	Information seeking (preferred sources, pre-incident); Predictors of preparedness behaviour	Hypothetical evacuation / Slovenia
Nasar and Greenberg, 1984	Survey (telephone) (80% response rate)	N=200	Random selection from local area phone directory; residents over 18 years	Evacuation adherence (anticipated); Sheltering adherence (anticipated)	Hypothetical nuclear attack / US

Nyaku et al., 2014	Survey (face-to-face) (91% response rate)	N=192	Residents within 50 miles of an NPP	Information seeking (preferred source, during incident); Perceived source credibility	No scenario used / US
Pearce et al., 2013	Surveys (telephone)	N=2005 (Britain: N=1000; Germany: N=1005); 56% female; mean age: 50·1 (SD=15·6)		Information seeking (preferred source, during incident); Perceived source credibility; Predictors of information seeking; Predictors of avoidance behaviour	Hypothetical RED scenario / Britain; Germany
Pheby & Robinson, 1990	Survey (postal) (44% response rate)	38% female (under-representation of older respondents)		Predictors of adherence with evacuation instructions	Hypothetical nuclear plant accident / UK
RTAC, 2008	Survey (unspecified)	N=502; 52% female; ages: 18 to 65		Information seeking (preferred source, during incident); Perceived source credibility	Hypothetical RDD scenario / US
Taylor et al., 2011	Survey (postal/online)	N=324; 48·5% female; ages: <25 to 65	Members of Australia Nuclear Science & Technology mailing list	Information seeking (preferred source, during incident)	No scenario used / Australia
Williams et al., 2005	Survey (telephone)	N=1071 (Females over represented: 60%)	Residents of the National Capital Region	Information seeking (preferred source, during incident); Perceived source credibility; Predictors of adherence with sheltering instructions; Predictors of adherence with evacuation instructions; Predictors of preparedness behaviour; Predictors of information seeking	Hypothetical RDD scenario / US
Zeigler & Johnson, 2010	Survey (telephone)	N=2595	Residents of Nassau and Suffolk Counties (vicinity of Shoreham NPP)	Evacuation adherence (anticipated); Predictors of adherence with evacuation instructions	Hypothetical evacuation / US
Studies involving actual events or published communication materials					
Cutter & Barnes, 1982	Survey (postal) (40% response rate)	N=359	Residents in 5 mile radius of TMI	Information seeking	Three Mile Island / US
Houts et al., 1980	Survey (telephone) (Survey 1: 75% response rate; Survey 2: 82%; Survey 3: response rate unreported)	Survey 1: N=692; Survey 2: N=1506; Survey 3: N=954 (sample close to national norm for heads of household age, gender, Hispanic ethnicity. Below norm for African American ethnicity, single status. Above norm for marital status, family size)	Survey 1: residents within 0-5 mile radius of TMI; Survey 2: residents within 0-55 mile radius of TMI; survey 3: unknown	Perceived source credibility; Evacuation behaviour (actual); Sheltering behaviour (actual)	Three Mile Island / US
Kanda et al., 2013iii	Survey (paper) (79·60% response rate)	N=1110; 29% female; ages: <30 to >60	Radiation seminar attendees; not subject to mandatory evacuation	Evacuation behaviour (actual)	Fukushima / Japan
Kanda et al., 2013i; 2013ii	Survey (80% response rate)	N=1119; 26% female; ages: <40 to >60	Health seminar (Fukushima Occupational Health Promotion Centre) attendees	Information seeking (preferred source, pre- and during incident); Predictors of adherence with evacuation instructions	Fukushima / Japan

Lasker, 2004	Survey (telephone)	N=2545 (Small differences between samples and corresponding estimates from 3-year averages (2001–2003)		Information seeking (pre- incident); Perceived source credibility; Predictors of adherence with sheltering instructions; Predictors of preparedness behaviour	Hypothetical RDD scenario / US
Miller, 1981	Survey (telephone)	N=248	Residents within 10 mile radius of TMI	Evacuation behaviour (actual); Predictors of adherence with evacuation instructions	Three Mile Island / US
Murakami et al., 2016	Survey (online)	N=9249; 46% female; ages: 20-69	Residents of Fukushima, Tokyo or Osaka	Information seeking (preferred sources, during incident); Perceived source credibility	Fukushima / Japan
Perko et al., 2012; 2014	Survey (Belgium: face-to-face; Slovenia: telephone)	N=1031 (Belgium; representative of population for province, region, level of urbanization, gender, age, and professional status); N=983 (Slovenia; representative of adult population for gender, age, education, level of urbanization, region)	Residents within vicinity of facility	Predictors of preparedness behaviour; Predictors of information seeking; Pre-incident knowledge; Predictors of risk information acceptance	Radio-isotope facility leak (Fleurus); KI distribution campaign (Belgium); Long-term radioactive waste disposal (Slovenia)
Perry, 1981; 1983	Secondary survey data: Nuclear Reg Commission (telephone survey); Rutgers; Michigan State University (postal surveys)	Not reported		Evacuation behaviour (actual); Sheltering behaviour (actual)	Three Mile Island / US
Prince-Embury, 1991; 1992i; 1992ii	Survey (paper)	N=117; 49% female; mean age: 41	Attendees of TMI Public Health and information workshop series on cancer, radiation and epidemiology	Perceived source credibility; Information seeking (during incident)	Three Mile Island / US
Rubin et al., 2012	Survey (online)	N=284; 28% female; ages: 18-46	British nationals living in or near Fukushima	Information seeking (preferred source, during incident)	Fukushima / Japan
Van Bladel et al., 2000	Survey (postal) (28% response rate)	N=1407 (representative of population, mostly male, > 80%, homeowners)	Residents within 20km of major nuclear installations	Predictors of KI use	Nuclear awareness campaign / Belgium
Vyncke et al., 2016	Survey (face-to-face)	N=938 (population representative sample)		Information seeking (preferred source, during incident)	Fukushima / Belgium
Zwolinski et al., 2012	Survey (telephone) (60% response rate)	N=153; KI users: 60% female, KI non-users: 59% female; Mean age, KI users: 63·3(SD=13.7), KI non-users: 60·1(SD=15·2)	78 free KI voucher users; 75 non-users; residents within 10 mile of nuclear plant.	Information seeking (during incident); Predictors of KI use	KI distribution campaign / US

Table 2.2. *Methodologies for studies (qualitative designs e.g. Focus Groups, interviews)*

Ref	Study Design	Participant demographics (if listed)	Inclusion criteria	Relevant topics of discussion	Event / location
Studies involving hypothetical scenarios					
Bass et al., 2015	Focus groups	N=37; 32% female; ages: 18–65	African-American; urban residential attendees of community centres	Predictors of instruction adherence	Hypothetical RDD scenario / US
Becker, 2004	16 Focus groups (12 w/ general public) (4 w/ first responders not included in review)	N=163 (focus groups total); 52% female; mean age: 42.6	12 public groups: 3 African American groups (2 urban, 1 rural); 3 white (2 urban, 1 rural); 3 Hispanic (2 urban, 1 rural); 1 Asian (urban); 1 English second language, 1 Indigenous American	Information seeking (preferred source, during incident); Perceived source credibility; Predictors of adherence with sheltering instructions	Hypothetical small IND scenario / US
Malešič et al., 2015	Semi-structured interviews	Not reported	Leaders of institutions (e.g. head teachers); residents within 3km of Krško NPP	Information seeking (preferred sources, pre-incident); Predictors of preparedness behaviour	Hypothetical evacuation / Slovenia
Oak Ridge, 2011	Focus groups	N=108; 48% female; ages: 25-54		Information seeking (preferred source, during incident)	IND message testing / US
Pearce et al., 2013	Phase 1: focus groups (7 British, 5 German); Phase 3: focus groups (using intervention leaflet)	Phase 1: N=52 (Britain), N=35 (German); Phase 2: N=570 (Britain), N=563 (Germany)	Britain: purposive sampling: parents/ travellers through mainline London train station; Germany: random selection from Stuttgart City Records	Information seeking (preferred source, during incident); Perceived source credibility; Predictors of information seeking; Predictors of avoidance behaviour	Hypothetical RED scenario / Britain; Germany
Rogers et al., 2013	Focus Groups	Phase 1: N=22; phase 2: N=64 (mix of gender, age, ethnicity, education and parents)		Information seeking (preferred source, pre-incident); Information seeking (preferred source, during incident); Perceived source credibility; Predictors of adherence with sheltering instructions; predictors of adherence with recommended actions (general)	Hypothetical RDD scenario / UK

Table 2.3. *Methodologies for studies (Experimental designs)*

Ref	Study Design	Participant demographics (if listed)	Inclusion criteria	Aims measured	Event / location
Studies involving hypothetical scenarios					
Bass et al., 2016i	Pilot test of decision aid tool	N= 50 (Intervention group: N=29; Control: N=21); 48% female; ages: 23-67	Low literacy adults recruited from community sites	Predictors of adherence with sheltering instructions	Hypothetical RDD scenario / US
Studies involving actual events or published communication materials					
Hellier et al., 2014	Field evaluation of leaflet (survey; focus group); (Survey: 16·5% response rate); Intervention: 8% response rate)	Survey: N=631; 55% female; mean age 53·2; Focus groups: N=30; 25 females; mean age 43·5; Intervention phase: N=112	Residents within radius of nuclear sites; higher and lower income households	Predictors of preparedness behaviour; Information preferences	Nuclear safety information leaflet distributed by NPP operator to homes within 2km radius; Trial leaflet / UK

2.3.3. Quality Assessment

Other than two papers, those using qualitative methods tended to score poorly for methodological robustness, with quantitative studies receiving a mixed range of scores. Studies generally scored poorly for adequate adjustment for confounding variables, quality of reporting, description of the distribution of principal confounders, and estimates of random variability. A number of studies using quantitative methods failed to report probability values. Studies scored particularly highly for the clarity of study aims and findings, and for selecting participants from the same population.

2.3.4. Predictors of behaviour in preparation for a radiation emergency

16 studies reported factors associated with preparatory behaviour (see Appendix B, Table B2).

2.3.4.1. Information seeking

One high quality survey (Lee and Lemyre, 2009) identified several cognitive factors associated with information seeking about nuclear emergencies, specifically the perceived probability and likely personal impact of an incident, one's perceived ability to cope, and worry. Perceptions of government or front-line preparedness were not associated with information seeking. In a study of people living near Three Mile Island, information seekers after the actual meltdown were found to be more highly educated but did not report the most worry about the radiation emergency that had occurred there (Prince-Embury, 1991). This study also scored well for quality though only examined a small sub-section of the US population living near to a nuclear plant.

2.3.4.2. Preparedness

Individual aspects of preparedness behaviour for hypothetical CBRN terror (such as compiling a first aid kit or supplies) have been variously associated with being older, a resident of rural areas, having higher education (Lemyre et al., 2007), and with the perceived probability of an incident, coping efficacy, perceived front-line preparedness, and worry (Lee and Lemyre, 2009). Few preparedness actions were found in residents near a nuclear facility who believed the site to be safe, but that in an emergency there would be no time to evacuate (Malešič et al., 2015). This study using a hypothetical scenario found a similar trend of low concern in residents living nearby to a nuclear plant (for example, see Prince-Embury, 1991, above), though scored poorly for internal consistency and reporting in quality assessment.

Mixed evidence was found for predictors of evacuation and sheltering preparedness in two further studies of hypothetical incidents, with preparedness being associated with having children under 18 years, whilst barriers to preparedness included denial of a threat existing, unwillingness to follow instructions and feeling unable to plan for the unknown (fatalism) (Guterbock et al., 2010; Williams et al., 2005). Notably, Guterbock's study scored considerably more highly for internal validity and adequate adjusting for confounders.

Collection and potential use of stable iodine was explored solely in studies of nuclear facility leak preparedness measures. One study found only 5% of almost 80,000 people living within ten miles of three Michigan nuclear power plants collected free iodine via a voucher system (Zwolinski et al., 2012). Non-collectors in this study had planned for a nuclear plant emergency to a lesser extent than collectors. Stated reasons for collection included preparedness (58%), safety (18%), the fact that it was free (14%), and because it was recommended (13%), though it should be noted that this is based on a small section of the sample. Reasons for non-collection included lack of awareness of its availability (36%), not receiving a voucher (12%), being 'uninterested' (7%) and feeling it unnecessary (4%). In an experiment, no difference was found between a standard nuclear safety leaflet and one supplemented with extra information about state-level preparedness in terms of how frequently they were kept or read by households which received them (Hellier et al., 2014). This was the only included study to conduct a randomised controlled trial on nuclear-safety information preferences, so no comparison data is available. The high quality of this research allows for some confidence in drawing conclusions however.

2.3.4.3. Adherence to evacuation recommendations

Two studies (Guterbock et al., 2010; Nasar and Greenberg, 1984) of hypothetical evacuation behaviour found that pre-incident warnings of an impending nuclear attack would prompt 66% of the affected population to leave, rising to 73% if warnings intensified such as via presidential message (Nasar and Greenberg, 1984), in contrast to 18%-19% for a radiological dispersal device attack, rising to 24% if warned by a 'top local official' (Guterbock et al., 2010). We might place more confidence in the outcomes of the higher quality scoring Guterbock study. Nonetheless, significantly fewer were suggested would evacuate if they learnt an actual attack was in progress (Nasar and Greenberg, 1984).

2.3.5. Predictors of behaviour immediately following a radiation emergency

23 studies tested factors associated with post-incident behaviour (see Appendix B, Table B3).

2.3.5.1. Information seeking

Among British nationals living near Fukushima, uncertainty about exposure to radiation or its hidden effects was found to cause distress and anxiety which were in-turn associated with heightened information-seeking behaviour (Rubin et al., 2012). Though it was the only included study exploring post-incident mental health effects and subsequent information seeking, it was amongst the highest scoring for quality.

2.3.5.2. Adherence to evacuation recommendations

The leak at Three Mile Island resulted in self-evacuation of 54% of the entire local population following an advisory that pregnant women and children should leave (Cutter and Barnes, 1982). Self-evacuees were more likely than those who remained to have attained high school education and be parents (Prince-Embury, 1992ii). There is varying quality amongst studies of Three Mile Island-related behaviour, though consistency in outcomes is apparent among them, other than the effect of proximity to a nuclear plant and its influence on evacuation behaviour, as outlined below.

The likelihood of evacuating during the TMI disaster decreased with age, increased with household size, and a significant association existed between behaviour and behaviour of neighbours. Stated reasons for evacuating were having received the advisory to do so (68%), fear of harm (46%), confusion (41%) and anticipation of a broader evacuation order with associated problems such as traffic gridlock (8%) (Cutter and Barnes, 1982). Three lower quality studies noted situational danger (cited by 30% (Perry, 1983) and 91% (Perry, 1981)) or concerns around forced evacuation (14% (Perry, 1983); 68% (Houts et al., 1980); 76% (Perry, 1981)) as reasons for self-evacuation. Reasons for non-evacuation were low perception of danger, fear of looting, waiting for an order for the general public to evacuate and believing oneself to be at a safe distance (Cutter and Barnes, 1982; Houts et al., 1980; Perry, 1981; 1983). Receiving conflicting reports was cited as both a reason to, and not to evacuate (Houts et al., 1980). Conflicting evidence exists as to whether close proximity to a nuclear power plant promotes or deters evacuation (TMI disaster: Miller, 1981; hypothetical scenarios: Pheby and Robinson, 1990; Zeigler and Johnson, 2010). Two reasonably robust papers and a third less so found actual (from Fukushima (Kanda et al., 2013iii)) and anticipated (Zeigler and Johnson, 2010) evacuees were more likely to be families with children under 19 and internet users (Kanda et al., 2013ii), also surveyed following the Fukushima disaster.

Similar findings have been reported in studies assessing intended evacuation in hypothetical scenarios involving deliberate attacks. Here, factors promoting anticipated evacuation have included: official announcements, news coverage, having children under 18 (Nasar and Greenberg, 1984) perceived likelihood of harm (Gerber et al., 2006) and following the actual TMI disaster disruption to telephone services (Miller, 1981). A majority of parents (55%) reported they would attempt to collect children from school during an incident even if knowledgeable about school evacuation plans and their children's location (Nasar and Greenberg, 1984).

2.3.5.3. Adherence to sheltering recommendations

Participants in three qualitative studies regarding hypothetical radiation attacks (two of high quality and concerning radiological dispersal device detonation) found sheltering recommendations counterintuitive, reducing their likelihood of adherence (Bass et al., 2015; Oak Ridge, 2011; Rogers et al., 2013). Trust in information source, perception and knowledge of the issue, checking information with trusted others (such as family and friends), family needs (Bass et al., 2015) and receiving a leaflet which included decontamination information (Rogers et al., 2013) tended to increase adherence. A fourth study noted reduced adherence to anticipated sheltering in ethnic minority groups following a deliberate attack due to a desire to gather the family together before attempting to evacuate (Becker, 2004). Confidence can be placed in these findings; each study being of particularly high quality.

Studies using quantitative methods found 8% of the population within 50 miles of a nuclear power plant (hypothetical scenario: Nyaku et al., 2014), 23% within 20km (preparedness communications evaluation: Van Bladel et al., 2000) and 33% in the US capital region (TMI: Miller, 1981) were unlikely to comply with sheltering instructions in a nuclear emergency (the differences in outcomes perhaps explained by the low quality reporting and internal validity assessed in each of these studies); 11% (Lasker, 2004) to 15·5% (Williams et al., 2005) in hypothetical radiological dispersal device incidents. More positively, this suggests a reasonably good level of compliance overall, although in this context, even a low percentage of the population not complying might translate into a large absolute number of deaths. Six studies (Guterbock et al., 2010; Lasker, 2004; Malešič et al., 2015; Nyaku et al., 2014; Van Bladel et al., 2000; Williams et al., 2005), three of high quality (Guterbock et al., 2010; Lasker, 2004; Williams et al., 2005), found prioritising collection or checking on children or other family members was a primary reason for non-adherence in both hypothetical nuclear accident and deliberate attack scenarios. Anticipated adherence would increase if people were able to communicate with, or know that loved ones were safe (Lasker, 2004) or if they believed that food and water would be delivered to shelters (Guterbock et al., 2010; Williams et al., 2005) in scenarios involving a deliberate attack. Further reasons for non-adherence with sheltering advice in both scenario types were low confidence or trust that community or government preparedness planning had been conducted effectively, feeling safer elsewhere, and to get supplies (Lasker, 2004; Miller, 1981; Nyaku et al., 2014). Two studies of radiological dispersal device detonation response (Lasker, 2004; Williams et al., 2005) found adherence with sheltering recommendations was predicted by community attachment, being over 65 and trusting the information source to provide accurate information. Adherence with sheltering-at-work was 39% (Williams et al., 2005) and was higher in those aware of their building's sheltering arrangements or those confident in their community's ability to manage a radiological dispersal device attack (Guterbock et al., 2010).

2.3.6. Preferences for information in the event of a radiation incident

26 studies examined information preferences (see Appendix B, Table B4).

2.3.6.1. Information seeking

Choice of information method and source Two studies explored preferred hypothetical pre-incident information distribution method, finding leaflets to be preferred by 62% of residents within 3km of a nuclear power plant (Malešič et al., 2015) and that residents of the US capitol region preferred local television and radio (25% and 21% respectively), general internet searching (28%) and family/friends (24%/21%) for radiological dispersal device information (Guterbock et al., 2010).

Two high quality focus group studies found preferred information methods and sources during a hypothetical nuclear attack would be the media (television/radio), internet, national level experts, word of mouth, emergency broadcast systems and local authorities (Becker, 2004), while young males would also seek out their peers (Bass et al., 2015).

Seven further studies explored sources during a radiation emergency using quantitative methods; high quality reports found friends or family, first responders (Taylor et al., 2011), internet news/government websites (Williams et al., 2005) in hypothetical scenarios and local or national media (Vyncke et al., 2016) during the actual Fukushima disaster were preferred. These findings are supported by four less robust surveys of both hypothetical and actual events (Carini, 2011; Kanda et al., 2013i; Nyaku et al., 2014; Radiological Threat Awareness Coalition, 2008). In a hypothetical radiological dispersal device emergency television network news and news or government websites were preferred; while social media, healthcare providers and the CDC were preferred by fewer than 2% (Guterbock et al., 2010).

Pre-incident nuclear information was found to be confusing and unclear in two studies (using focus groups (Becker, 2004) and an experimental design (Hellier et al., 2014)). For example, participants did not fully understand the terms, 'shelter-in-place' and 'plume'. In one experiment with low-literacy ability individuals, the participants were randomly assigned to an intervention group in which they received a literacy-appropriate aid or to a control group in who received a CDC factsheet. A questionnaire tested understanding of the material which was compared across groups related to gaze patterns and time spent reading as well as perceived confidence in understanding (such as how to respond in a dirty bomb scenario) and subsequent intended behaviour. Higher confidence in understanding terms, how to respond and perceived ability to carry out instructions was seen in those with the very lowest literacy in the intervention group (Bass et al., 2016i). In a second RCT, participants were presented with either the original nuclear safety information leaflet or a trial leaflet developed following an RCT examining preferences for information content. Pre-test memory for and understanding of nuclear safety information were assessed. The dependent variables tested were intention to act in relation to safety advice, self-reported understanding of the information presented, leaflet preference as well as memory being assessed again at the study period and following the study. The trial leaflet was found to be preferred by residents of homes within 2km of a UK nuclear power plant due to greater ease of understanding, being more informative, offering a pin-up summary, and using preferred pictures and layout (Hellier et al., 2014). Studies using focus groups and hypothetical radiological dispersal device scenarios found leaflet length, density and complexity, lack of illustrations, accessibility for disabilities (Pearce et al., 2013) and recommendations without explanation (Rogers et al., 2013) to be criticisms, whilst a live voice delivering messages was preferred to a recording during a hypothetical incident (Oak Ridge, 2011).

Preferences for information content In hypothetical pre-incident scenarios 77% of the US public expressed interest in knowing government and community radiological dispersal device response plans (Lasker, 2004) whilst 77% of participants presented with a scenario in which radiological materials were found in possession of terrorists would seek health-related information (Pearce et al., 2013).

After the incident at Three Mile Island (Cutter and Barnes, 1982), some residents (number not reported) sought information on impact, while British nationals in Japan made requests for consistency in information across communicators, clarity regarding safety concerns and regular updates during the Fukushima disaster (Rubin et al., 2012). In a hypothetical nuclear emergency, guidance on countermeasures and food safety would be sought by 86% of Italian respondents (Carini, 2011).

One focus group study using a hypothetical radiological dispersal device emergency found desired information to include protective actions according to distance from the site of the incident, water and food contamination risk and actions of authorities (Rogers et al., 2013).

2.3.6.2. Perceived credibility of information source

Multiple studies explored trust and credibility in hypothetical radiation disasters. Their results varied: UK non-governmental sources (Pearce et al., 2013), scientists (also rated most competent alongside authorities (Latré et al., 2018)) and the US President (Guterbock et al., 2010) all tended to be rated as most trustworthy, followed by local public health departments (Nyaku et al., 2014) and national news/media (Radiological Threat Awareness Coalition, 2008; Williams et al., 2005). Least trusted to provide honest and accurate information were US national media and local (US) authorities (Bass et al., 2015; Guterbock et al., 2010), nuclear industry (Latré et al., 2018), local religious leaders and government (Radiological Threat Awareness Coalition, 2008; Williams et al., 2005).

In general, increased trust in the advice itself was associated with consistency between messengers and messaging from authorities, such as expert medical advice (Rogers et al., 2013), whilst perceived reliability was associated with the use of basic terminology during the TMI disaster (Prince-Embury, 1992i), and increased confidence with recommended protective actions having been proven effective in a hypothetical scenario (Becker, 2004). A series of studies demonstrated that acceptance of information during an actual radiation leak was predicted by one's level of agent-specific knowledge, trust in the message source (Murakami et al., 2016; Perko et al., 2012), whether the disaster is assumed to have low potential to cause personal harm and being from a directly affected population (Perko et al., 2014).

Regarding information preferences of different subgroups, in one particularly high scoring study using communication materials, Bass (2016ii) found low literacy (mostly ethnic minority) survey respondents fell into three categories based on their perceptions of information sources and anticipated adherence to recommendations: those most likely to trust that information is accurate and to adhere to sheltering instructions despite believing that authorities are unlikely to provide them with the same level of support as they do others; those least likely to adhere or prepare out of distrust in authorities as a source, and their information and; those likely to adhere to sheltering instructions given by local, but not national sources.

2.3.7. Theoretical Domains Framework

I used the Theoretical Domains Framework to help analyse the review outcomes and as a tool to inform the topic guide for the next phase of this study which was based on qualitative research using focus groups. Table 2.4 shows the final ranking of each of the 14 domains of the Theoretical Domains Framework based on the outcomes of this review. The table includes the number of studies that refer to each of the domains.

Table 2.4. *Ranking of TDF domain frequency in systematic review outcomes*

Rank	Domain	Number of studies referring to domain
1	Memory, attention and decision processes	38
2	Social / professional role identity	30
3	Knowledge	23
4	Beliefs about consequences	18
5	Emotion	15
6	Environmental context and resources	14
7	Beliefs about capabilities	9
8	Social influences	7
9	Intentions	2
10	Reinforcement	2
11	Behavioural regulation	1
12	Goals	1
13	Optimism	1
14	Skills	0

2.4. Discussion

How the public would behave immediately following a catastrophic nuclear or radiological incident is uncertain. For example, in a hypothetical radiological dispersal device or nuclear scenario most people in the US capital region report that they would shelter-at-home or in their workplace (Guterbock et al., 2010; Miller, 1981). In contrast, actual nuclear incidents have seen self-evacuation to be common, particularly among those receiving information felt to be confusing or unclear (Becker, 2004; Cutter and Barnes, 1982). Further complicating factors highlighted in this review is the issue of cultural differences as a potential influence on adherence, particularly since the two actual nuclear plant meltdown scenarios from which adherence data was collected came from eastern (Fukushima) and western (TMI) locations. Though the literature of cultural differences in CBRN response is limited, insights may come from studies of health-regime compliance in which only 'superficial' difference (Oh, 2013) is found in adherence rates, although adherence is found to improve when the source of medical information (such as the general practitioner) is felt to be culturally competent (Nilchaikovit et al., 1993; Ohana and Mash, 2015). Exploration of adherence across cultures in response to risk communication by Harro-Loit and colleagues (2012) found adherence following events including a hypothetical nuclear disaster to be dependent more on emotional, proximate/distal and knowledge-based experience which are influenced by cultural background. Where differences are found to exist, it is not in terms of overall adherence rates, but instead in consistency, wherein more individualistic participants who undertook a short survey showed stronger consistency when later asked to complete a longer survey than more collectivistically oriented participants (Petrova et al., 2007). Finally, and relating directly to terror attack response, no difference was found across cultures in individuals affected by the World Trade Centre attacks of 2001 (Walker & Chestnut, 2003). Given the likely link between behaviour and the overall health effects of a nuclear incident, this reinforces the suggestion in Chapter 1 that encouraging protective behaviours should be a priority. The public's willingness to engage in protective behaviours in the event of a nuclear disaster will be explored in subsequent chapters of this thesis.

Encouragingly, rates of information seeking suggest a desire amongst the public to learn protective actions (Becker, 2004; Carini, 2011; Lasker, 2004; Lee and Lemyre, 2009; Pearce et al., 2013; Rogers et al., 2013). This includes a wish to understand pragmatic issues, many of which could only be addressed after the specifics of an incident are understood. Some aspects could be addressed prior to any incident, however. In particular, one study of public communication around nuclear power plant emergencies suggest that participants had a desire to better understand risk (such as of the event happening) (Cutter and Barnes, 1982) whilst regarding a deliberate attack there was a clear desire to understand the threat (such as the likelihood of harm coming to those not directly affected) (Rubin et al., 2012). Immediately following the Fukushima emergency, for example, more than one-third of questions posed over the internet sought radiation-related knowledge (Ohno and Endo, 2015).

Yet are the public receptive to messages about radiation or protective behaviour in advance of an incident occurring? As we saw in Chapter 1, theories surrounding the uptake of protective behaviour in other contexts suggest that certain pre-requisites may be required before messages are attended to or acted on. These include perceived threat and a perception that the recommended behaviour may be effective (e.g. Lee and Lemyre, 2009). In the absence of such conditions, information campaigns may be ignored or quickly forgotten (Rubin et al., 2005). In contrast, public information campaigns can increase knowledge (Bass et al., 2016i; Železnik and Perko, 2012), which may increase receptivity to future messages when a threat becomes more apparent (Perko et al., 2012). Certainly, in the literature I have reviewed, perception of risk appears to be an important predictor of behaviour. While there is literature in the health behaviour field to suggest that perceived risk and subsequent behaviour are not necessarily linear (e.g. Deese et al., 2018), in this review it appears that there is an influence of risk perception on: acceptance of messages (Perko, 2014), taking preparatory measures (fewer in those with high radiation risk perception: Malešič et al., 2015), self-evacuation (Gerber et al., 2006) and information seeking (Pearce et al., 2013). Communicating with the public while perceptions of risk are low may result in messages being ignored. Nonetheless, if pre-incident communication is to be used, these results do offer guidance regarding what information should be given and how it should be conveyed.

2.4.1. Source and Method

A trend for greater preference for traditional media sources exists for pre-incident information relating to nuclear power plant emergency preparedness than for attack scenarios, whereas a small number of reasonably good quality studies found that more would seek information using the internet if an attack were to occur. However, the shift towards public preparedness against catastrophic terror in the risk communication literature, precipitated by the World Trade Centre attacks in 2001 coincided with the rise of the internet and social media. We might therefore predict this to be a stronger trend than is evident in this review.

Changes over time in communication technology inevitably raise questions about applicability of older findings to the current context. Nonetheless the general point raised by many studies would seem to remain true: people will seek information from sources they trust. To build upon this, the synthesis of studies examining trust in this review show that there is an interaction between a trusted source of information and trust that the message is accurate in terms of recommended actions. Providing information from sources that are most trusted will mean information is more readily accepted and adherence to instructions more likely to occur.

Receiving messages from trusted sources was highlighted in multiple studies, though opinions inevitably differed as to who is trusted. A comparison of sources (Latré et al., 2018) found government authorities were viewed as most credible (and were a preferred pre-incident source: Carini et al., 2011; Guterbock et al., 2010; Kanda et al., 2013i; Nyaku et al., 2014; Radiological Threat Awareness Coalition, 2008; Williams et al., 2005), although scientists were considered more trustworthy than authorities and nuclear industry, and equally competent as nuclear industry. The nuclear industry, despite being perhaps best placed to provide information regarding radiation safety, appear least trusted to do so. If an incident were to occur, the public also want to hear from sources with knowledge particular to them and their area, such as local media, local authorities or friends and family. This suggests a primary concern in knowing how personally affected they might be as opposed to the national situation.

Given this heterogeneity, perhaps the best that can be recommended is the old adage of multiple sources speaking with one voice (e.g. IAEA, 2012); having messages endorsed by multiple experts and agencies increases the chances of them being accepted. In today's media climate this approach may be difficult to achieve. In many instances, the media actively seek out opposing views (Smith, 2005), oftentimes subjective in nature (Prezelj, 2016), which increases distrust of scientists and public health messages (Mythen, 2004). The finding that scientists appearing on national media lost credibility (Pearce et al., 2013) highlights this point. This is interesting as Pearce studied preferences across samples from two separate, though both Western, countries (The UK and Germany). It is perhaps unrealistic to expect one-voice communication to occur in an incident of this nature. The 2018 false alert of a nuclear attack in Hawai'i is an example in which the authoritative voice was one of many and was arguably lost amongst social media feeds.

Prezelj et al (2016) found reporting of the Fukushima disaster in Europe received limited public information coordination, warning that failure to fully address these limitations is likely to result in 'symbolic readiness' and insufficient preparedness. Prezelj suggests that the 'one-voice' approach such as that presented in IAEA guidelines (2013ii) offers false expectations of the effectiveness of future nuclear risk communication in which the IAEA would be one of many voices. This perhaps supports the apparent need for corroboration of information from peers as was found in one study conducted in the US (Bass et al., 2015). Ideally, different endorsements are needed for different groups. For example, one high quality study (Bass et al., 2015) conducted with low-income residents of urban areas found most trust in local media as a source and a need to have an established community spokesperson endorse authority recommendations further.

2.4.2. Content and format

Two experiments were included in this review both of which found clarity and ease of understanding were commonly requested both pre- and during incident messaging. This was a pressing concern among low literacy individuals who might require decision-aided materials; that is information visually designed to be information appropriate in content while fitting the existing perceptual maps of participants and is intended to improve knowledge of actions and intention to adhere to sheltering instructions (Bass et al., 2016i). The need for clear messages was also expressed within the wider public. Consistency in messages within and across sources is also desirable and associated with adherence to recommendations (Bass et al., 2015; Perry, 1981; 1983). Inevitably, much more information is desired immediately following an incident than pre-incident, relating to issues such as food and water contamination (Carini, 2011), actions of authorities and recommendations specific to where the individual is at that time (Rogers et al., 2013), as well as regarding the likelihood of further attacks (Pearce et al., 2013).

The other experiment, a study of the effectiveness of a pre-incident communications leaflet (Hellier et al., 2014) found advisories best recalled were arguably those with the most personal impact on the recipient, such as not collecting children from school and not using mobile phones. Instructions less well recalled (e.g. to take stable iodine if told to) are perhaps considered out-of-the-ordinary in terms of activities undertaken regularly, or are ones not previously considered. Other criticisms of leaflets such as excessive length, density and complexity, lack of illustrations, accessibility issues for disabilities and recommendations backed up by facts without explanations represent potential barriers to the reception of information; however, whilst recall of certain advisories increased with a developed leaflet, no significant difference in intended adherence or understanding was found.

Several instances of apparent fatalism hindering the likely uptake of messages were found. For example, many individuals living close to a nuclear power plant felt that preparing for an emergency was not worthwhile since they would not have time to evacuate (Malešič et al., 2015) and were disinterested in collecting free stable iodine (Zwolinski et al., 2012). These findings, in non-UK population samples would benefit from further exploration in providing more robust evidence for desire and preferences in pre-nuclear incident communications in the UK. For example, the early 2020 Covid-19 pandemic has shown that the public’s willingness to change behaviour in the face of potentially existential crisis may be underestimated and even be more a question of opportunity to adhere, not necessarily motivation (e.g. Webster et al., 2020) However, based on the outcomes of this review it appears that to encourage preparedness, pre-incident communications should provide information regarding the efficacy of the suggested behaviour. This may require a degree of education about the nature of radiation, the mechanism underlying the benefits of stable iodine, conditions under which evacuation or sheltering would be appropriate and how people might be informed as to which action is recommended depending on the nature of the incident.

Greater detail in communications regarding the processes that survivors who are exposed to radiation might experience, such as an explanation of decontamination procedures (Rogers et al., 2013), may increase adherence. Adherence to recommendations will likely increase if the public can be reassured, for example, that food and water can be delivered to them whilst sheltering (Pheby and Robinson, 1990) or that they can be evacuated to somewhere where support will be offered. This extends to psychological support (Malešič et al., 2015).

In addition to neighbours and friends influencing behavioural responses, with individuals looking to the actions of others to inform their own decisions, family needs are fundamental in shaping actions. Several studies (Cutter and Barnes, 1982; Gerber et al., 2006; Guterbock et al., 2010; Lasker, 2004; Nasar and Greenberg, 1984; Perry, 1983; Rogers et al., 2013; Van Bladel et al., 2000) identified a desire to collect children from school and make contact with loved ones, even at the expense of increasing exposure to radioactive material. This latter phenomenon has been observed in previous non-radiological incidents (Rubin et al., 2005) and must be addressed in pre-incident communications, perhaps by providing parents with information on the responsibilities and emergency plans of schools for protecting children.

2.4.3. Gaps in understanding

Gaps emerged from the literature that appear central to our understanding of effective public communication in the pre-incident phase. One gap relates to use of social media in radiation emergency communications. Social media is likely used by a large number who would choose the internet as a source and method of information gathering following an incident. It is unclear at this stage to what extent social media could be used to disseminate and promote pre-incident public education for radiological and nuclear emergencies. Secondly, more data is needed on how different information sources can foster trust in the public. Trust is central to whether information is accepted and recommended actions adhered to. Previous studies have largely quantified levels of trust in sources and few have explored the facilitation of trust, or distrust.

The longer-term impact of any information campaign is a third key knowledge gap. Hopefully, any pre-event messages that are disseminated will never need to be used. However, maintaining knowledge over time is important. To date, studies have generally only focused on the immediate impact of messages. Whether messages about high impact events which later do not come to pass have a wider, detrimental, effect on the credibility of future messages on related issues is also unknown (Rubin et al., 2015). This presents a challenge for communicators, and the frequency with which messages need to be repeated and reinforced is an area worthy of further investigation.

Whilst this review provided evidence for what factors influence behaviour (actual or anticipated), we are, of course, constrained by what the existing literature tells us. In considering theoretical drivers for behaviour in the context of the TDF we find that the literature provides little or no evidence for the impact of intentions, reinforcement, behavioural regulation, goals, optimism or skills as is shown in Table 2.4. In future these domains of behavioural motivation might benefit from being studied, however they will not be focussed on in this thesis. This table is intended to be used as a guide in the development of materials for the first phase of original data collection in this PhD: focus groups with members of the public. Particularly, the review data will aid in the development of a topic guide for discussion. For example, predictors most commonly found in the previous literature to present barriers to message engagement, preparedness or adherence can be probed for reasons why, and for ways in which such barriers might be overcome.

Finally, this review highlights the apparent narratives of nuclear disaster preparedness and the importance of adding to the public discourse and societal representations, or mental models, of such emergencies. This will help the public to become more informed and importantly, better able to prepare for nuclear disasters.

2.4.4. Limitations

Relatively few studies included in this review provided evidence about actual behaviour. Those that were available often suffered from methodological deficits, possibly related to their reactive nature and the need to begin research promptly during the immediate period following an emergency. It was therefore necessary to include anticipated behavioural responses from hypothetical scenarios in drawing conclusions. Arguably, studies using hypothetical scenarios are flawed: how can members of the public be expected to know how they would react or what information they would want in such extreme circumstances? A possible counter to this flaw is that many of the studies used well researched and realistic scenarios such as those based on modelling and plume calculations in their studies; yet the difference between viewing a news report of a real attack taking place versus watching it from the comfort of a focus group is inescapable. In exploring anticipated adherence and information needs in a radiation emergency, hypothetical studies make up the majority of research in this area. Though the methodological quality of hypothetical scenario studies in this review was stronger than that of studies from actual events in most instances, this limitation must be considered in the interpretation of results.

The following questions were excluded from quality assessment using Downs and Black's checklist: *Have all important adverse events that may be a consequence of the intervention been reported?; Have the characteristics of patients lost to follow-up been described?; Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?; Was an attempt made to blind study subjects to the intervention they have received?; Was an attempt made to blind those measuring the main outcomes of the intervention?; In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?; Was compliance with the intervention/s reliable?; Were study subjects randomized to intervention groups?; Were losses of patients to follow-up taken into account?* These questions were excluded from quality appraisal as it was found from conducting the appraisal that studies were consistently scoring 0 for each. It was assessed therefore that these questions were not appropriate to the nature of the studies included in this review. I am confident therefore that the scoring of the included studies would remain consistent with or without the inclusion of these questions. It was deemed appropriate to take this approach as the original publication of this checklist stated that 'Most of the questions could be asked of any analytical study of any health care intervention…. (some) were inevitably topic sensitive and had to be customised'. Furthermore, a number of studies have modified this checklist to meet the aspects of studies included in their own systematic reviews. Despite these adaptations, I felt that use of Down's and Black's quality checklist remained justified as it has been identified in Deeks et al (2003) as amongst the most highly rated tools (in a sample of 213 tools) for quality assessment of both randomised and non-randomised research designs, meeting most of Deeks' criteria for internal and external validity. In addition, the Centre for Reviews and Dissemination Guidance for Undertaking Reviews in Healthcare (2009) found Downs and Black's checklist to be one of only 3 (out of 200 reviewed) to be suitable for quality assessment of studies using a cross-sectional design and to ‘(have) been extensively validated’ in Systematic Reviews in the Social Sciences: A Practical Guide By Mark Petticrew, Helen Roberts (2006).

One observation of study quality was the absence of effect sizes reported for some studies using quantitative methods. This made comparison between study outcomes difficult, allowing me to judge only whether findings were generally in the same direction. Future research in this area should address this to ensure direct comparison can be made between populations.

The literature would also benefit from variation in the populations studied: few studies explored information preferences across populations with potentially differing information needs. In addition, few studies used mixed methods; meaning information gathered regarding potential predictors of behaviour by use of one method (such as using focus groups) were not explored further in terms of strength of predictors.

Resource availability meant that I could only include studies published in English. There are likely to be studies conducted in other countries that have experienced nuclear incidents or a nuclear threat (e.g. Japan and South Korea) where efforts to prepare the public have been ongoing for some time. A recent study of ecological meta-analyses found that including only English language studies caused a bias in analyses due to differences in study characteristics and effect-size estimates (Konno et al., 2020). It could be argued that if non-English abstracts were found to be highly relevant through automatic translation apps, it would have been appropriate to translate those articles to gain additional insight. A future review should seek to identify studies published in languages other than English, focusing particularly on countries that have been observed to implement pre-incident public information campaigns. In this review, only two studies were excluded following initial key-word search on the basis of language.

Finally, no formal double checking of included studies was undertaken and so no kappa score was calculated.

2.4.5. Recommendations based on the findings of this review

Several practical implications can be drawn from this review. Whilst these are outlined below, I will return to these recommendations in the final discussion chapter of this thesis and update them in line with the new insights generated by the studies presented in Chapters 3 to 5.

- Perceived risk was found in many studies to differ across populations. Pre-incident communication regarding preparedness actions should therefore be targeted at the recipient population (i.e. residents close to a nuclear power plant should receive advice regarding stable iodine collection and use)

- Studies that explored understanding of terminology and recommended actions found the public to vary in their comprehension of terms used. Therefore, advisories as to potential actions (evacuation; shelter-in-place) should include details as to how individuals can find out which action is most suitable to them (such as based on their location to the emergency), and who they can expect to give this information
- Low trust in information sources or in the efficacy of protective actions was often found to result in poor (anticipated) adherence. Information regarding recommended actions should clearly explain reasons why these might be advised, including the circumstance under which there might be a danger in non-adherence
- According to the studies in this review, preferred methods of distribution are likely to differ: pre-incident information will benefit from being accessible in the public's own time such as leaflet, letter or website information, whereas information distributed during an incident are likely to involve a preference for internet communications
- Information seeking was found to be common amongst the public in radiation emergencies which present fear-inducing and uncertain circumstances. Information should minimise uncertainty in the public by outlining frequently requested information including exposure effects (means of contamination; symptoms), protective actions to take and the length of time people may potentially be required to shelter
- One major study found that groups with low-literacy skills are at risk of harm due to not understanding information presented to them. Pre-incident information should include links to further information including low-literacy aided and preferred language materials
- Basic terminology should be used in all communications to minimise misunderstanding amongst all recipients
- In studies that explored it, a desire to be with or collect loved ones, particularly children, was expressed amongst parents. Information should specifically address the impact on families/children such as protective actions for parents/caregivers to take, actions to take if children are at school in an incident and health effects for children
- To address a common point of uncertainty expressed in the included studies, food and water contamination should be addressed in communications including what could safely be consumed

- Studies have shown no clear preference amongst the public for a particular source to communicate pre-incident preparedness materials. Therefore, combined sources may be used in presenting information: for example, messages presented by recognised government officials should cite health protection agencies and/or nuclear industry sources
- However, where multiple sources make information available, a consistent message must be relayed to promote trust in communicators
- Studies found that communications will not be engaged with in the pre-incident period by many who are instead more likely to engage during an emergency, or information will be forgotten when required. Therefore, information presented in the event of a radiation emergency should echo information presented pre-incident with reassurance given that if pre-incident communications were not received or have been forgotten that there are ways of accessing them still (if opportunity allows)

2.5. Conclusion

This review highlights factors that could increase engagement with key messages and promote the uptake of protective behaviours and emergency interventions that will save lives in the unlikely event of a catastrophic radiation emergency. The first step in achieving this would be additional research in the UK to explore preferences amongst the public for pre-incident communications regarding nuclear emergency preparedness. Without consideration of best practice in such communications, a catastrophic incident could become worse than we currently fear; it is essential that further research and planning for how the public should be informed of protective actions in the event of a nuclear emergency is undertaken; this is the focus of the studies presented in subsequent chapters in this thesis.

Chapter 3: What do the UK public want to know about nuclear catastrophe preparedness? A focus group study

The systematic review detailed in the previous chapter has highlighted a number of recommendations as to how communications might be delivered to the public before and at the time of a disaster involving radiation. It also has provided an insight into how the public might behave in such incidents. Building on this knowledge, this chapter will detail a series of focus groups conducted with members of the public to explore how pre-nuclear incident communications might be most effective in eliciting preparedness and desired behavioural response. The groups were designed to further refine the findings of the review but to also develop our understanding of the underpinning psychological frameworks that drive motivation towards preparedness and adherence to recommended protective actions. Specific areas that these groups aimed to address included: what the perceived risk of a nuclear attack is among the public (and whether this motivates a desire to receive pre-nuclear incident information); what UK-based sources are preferred to communicate preparedness information (a wide and inconsistent range are reported in the literature); what specific information might be contained in messaging and; how it might be presented.

3.1. Background

3.1.1. Incidents and populations to study

In the systematic review (Chapter 2) I showed that despite nuclear terror representing a catastrophic threat, there has been little research on how best to prepare the public. Studies involving the development of public communication materials have primarily explored preparation for smaller scale, 'dirty bomb' incidents (e.g. Bass et al., 2015; Lasker, 2004; Pearce, et al., 2013; Rogers et al., 2013) though exceptions exist. Two such studies, both in the US, used focus groups to explore preferences amongst the public for information distributed only in the immediate aftermath of an improvised nuclear device attack (Becker, 2004; Oak Ridge Institute, 2011), not prior to it.

Although agencies such as the International Atomic Energy Agency (IAEA) have since developed materials (IAEA, 2014) for pre-incident information, there was no direct public contribution to their development. Certainly, no studies have used UK participants for this purpose. Nor is there publicly available evidence of focus groups having been conducted to identify public information needs in a nuclear emergency following an accidental release from a nuclear power plant, rather than deliberate attack.

These routes of potentially catastrophic radiation exposure possess differing characteristics. Each will likely have an immediate effect on different populations: nuclear plants are located away from large, urban areas, whereas a deliberate attack on the public using a nuclear device would more likely occur within an urban, densely populated area. Injury may occur via different means also. A deliberate attack would involve radiation dispersion coupled with an explosion; the blast effects would likely result in injury or death by way of smashed glass or overturned vehicles (e.g. Glasstone and Dolan, 1977). Blast effects, if occurring, would be unlikely to affect the public in a nuclear power plant radiation leak.

In the systematic review, I found varying levels of anticipated adherence with protective instructions, high levels of information-seeking behaviours during a radiation emergency and a general lack of preparedness to have been previously reported among the public.

Several factors were associated with these behaviours, which give some indication as to how a communication intervention to improve preparedness might best be designed. This includes: trust in the source of communications (Florig and Fischhoff, 2007; Lasker, 2004; Rogers et al., 2007), found to influence source preference, and engagement with, and adherence to, instructions (Latré et al., 2017; Murakami, 2016; Perko et al., 2013; Rogers et al., 2013); the method by which information is distributed (e.g. social media/internet after an incident (Lee and Lemyre, 2009) or traditional media and leaflets pre-incident (Perry, 1981)); the content and format of messages, such as pin-up summaries, colour and images (Bass et al., 2016i; Hellier et al., 2014); perceptions as to the effectiveness of recommended actions (Rogers et al., 2013; Taylor et al., 2011); risk perception (Gibson et al., 2007; Železnik and Perko, 2012); and attitude or belief of the recipient (e.g. fatalism (Nasar and Greenberg, 1984)). I also outlined how these outcomes map onto the Theoretical Domains Framework (illustrated by Table 2.4 in the review chapter and by tables in Appendix C).

Whilst these findings offer important insights into the facilitators and barriers to acceptance and reception of nuclear preparedness communications, most literature reviewed in Chapter 2 was not specific to the UK population. In fact, reports of the UK public's perception of nuclear risks and guidance regarding protective actions is sparse. Instead, UK-based studies of nuclear risk perception are largely focussed on issues surrounding the siting of nuclear plants (e.g. Grimston et al., 2014; Leonard and Thomas, 2017).

There are some exceptions to this. In focus groups with UK residents presented with a dirty bomb detonation scenario followed up with a nationwide telephone survey, Pearce et al (2013) found perceived delays between exposure and health impacts and radiation misperceptions (such as contamination methods) caused uncertainty, anxiety and behaviour change detrimental to public health efforts. Rogers et al (2013) used focus group findings to design dirty bomb preparedness materials which increased anticipated adherence to attend a treatment facility. Rubin et al (2012) explored psychological symptoms in UK nationals present in Japan during the Fukushima plant disaster of 2012. They found uncertainty, inability to rule out radiation exposure and receiving information from sources believed to lack credibility was associated with distress, anxiety and anger. Anticipated behaviour was examined by Pheby and Robinson (1990) who found many would ignore sheltering advice to self-evacuate whilst others reported no means or desire to evacuate. Only Hellier et al (2014) has published results of a study exploring communication with the UK public specifically for nuclear emergencies (in this case, for accidental plant leaks). They found low recall of safety advice with some improvement following distribution of a trial leaflet developed using existing guidelines for improving public communication.

Given the lack of evidence as to how best to encourage preparedness and adherence to protective advice in the UK population, I used a series of qualitative focus groups in this study to collect data to provide the basis for a future information campaign.

3.1.2. Research questions

This study had the following broad objectives:

1. (aligning with the first of the project aims) to identify possible predictors of behaviour in the preparedness and immediate stages of a nuclear emergency;

2. (aligning with the second of the project aims) to identify what factors might promote engagement with pre-nuclear incident communications;

3. (aligning with the second of the project aims) to identify the preferred pre-incident information distribution method among the public;

4. (aligning with the second of the project aims) to identify factors that promote trust in the message and perceived source credibility.

This research proceeded in two stages. First, I used public and patient involvement to test and refine the proposed study design. Second, I conducted eight focus groups with members of the public.

Focus groups were chosen as a methodology since they produce data through interaction, appropriate to the social nature of this subject (Finch et al., 2014). Socially-driven factors such as actions taken by neighbours (e.g. Prince-Embury, 1992) and seeking information from friends and family (e.g. Rogers et al., 2013) influence behaviour in the event of a radiation emergency. As Hydén and Bülow (2003) state, focus groups aid in our understanding of *'how attitudes and opinions are created and sustained through interaction with others'*. Murphy et al (1998) suggest that qualitative methods enable a fuller understanding of rationales (why), processes (how) and contexts (when), such that cannot easily be elicited by quantitative methodology. Though Murphy's description concerns patients' interactions with health care services, it is equally applicable to the aims of this study, intended to explore 'why' the public would require pre-incident information, 'how' they would prefer to receive information, and 'when' it might be best received.

3.2. Public Involvement

3.2.1. Introduction and aim

The UK's National Institute for Health Research (NIHR, 2014) states that the public can contribute to research by, amongst other things, '*offering advice as members of a project steering group, commenting on and developing research materials*.' Public involvement in research allows for the conducting of research '*with*' or '*by*' the public, rather than research that is '*for*' or '*about*' them. This also allows for identification of differences between public perspectives and those of health or social care professionals (NIHR, 2012). By actively giving voice to the public we might better understand what is important to them in research.

Public involvement is the term that is used to describe researchers and members of the public working together to develop research which is relevant to public and patient need. Active involvement of the public can occur in any stage of the research process. Ethical approval for public involvement activities is not required (NIHR, 2014). Many organisations who undertake health research in the UK hold a pre-existing public panel who have agreed to be called upon to assist in these activities.

Use of a public involvement group during the development of this study provided an opportunity to obtain feedback and guidance regarding the proposed procedure and materials. This was not considered a 'pilot' study as it contributed to the process of development of group materials.

The objectives of using a public involvement group were:

- To identify key priority points within the topic guide to be used in focus groups;
- To test the suitability of the scenarios to be used;

- To ensure the timings of the group were accurate;
- To receive feedback on my own moderation and facilitation techniques and;
- To become further accustomed with the topic guide.

3.2.2. Method

3.2.2.1. Design

The public involvement discussion took place on September 6th, 2017 at the Public Health England offices at Wellington House, Lambeth, close to London Waterloo railway station. Initial drafts of the scenarios and topic guide were used.

3.2.2.2. Participants

Public Health England (PHE) has an established public involvement database of individuals willing to assist the Emergency Preparedness and Response Department in research development activities, some with experience of focus group participation and public health matters, from which group members were drawn.

Twenty-three individuals replied to an invitation e-mail sent to this database. Six participants were purposively selected to provide a wide-ranging demographic profile (two women and four men), with ages ranging from 20 to 75, who were of Asian British, Bangladeshi and White British ethnicities. Two reported having school age children.

3.2.2.3. Materials

Participants were provided with the following materials to review and comment on:

- Study consent form and information sheet and;
- Two draft scenarios.

An ‘urban’ improvised nuclear device detonation scenario was provided, based on Scenario #1 of the 15 Department of Homeland Security (DHS) national planning scenarios (DHS, 2005) and the FEMA Planning Guidance for Response to a Nuclear Detonation (FEMA, 2010). This has been checked for realism and scientific validity by experts in the field (e.g. Buddemeier & Dillon, 2009) and is widely employed in modelling scenarios (e.g. Buddemeier and Suski, 2015).

The scenario was adapted for relevance to a UK audience. Participants were told to imagine that they had heard an explosion but not witnessed it directly, although a mushroom cloud is seen following the blast. This suggests a nuclear blast occurring several miles from the participant’s location. Detonation of a 10KT nuclear weapon outside London’s Waterloo Station would result in a damage radius of 2.5 miles. This would extend the reach of the blast radius to an area defined by FEMA as just outside of the moderate damage zone into the light damage zone (FEMA, 2010). The estimated population within this defined area is 602,529 people (Freemaptools, 2017). This scenario is in Appendix D.

In the second scenario, participants were asked to imagine that they had heard of a '*partial meltdown*' at an unspecified nuclear power plant over the radio. The scenario included some technical information specific to the incident and a sentence relaying recommended protective instructions. The scenario is also detailed in Appendix D.

3.2.2.3.1. Topic Guide Design

A topic guide was informed by the systematic review (Chapter 2) findings as outlined above, with additional items relating to the domains of the Theoretical Domains Framework (TDF) where relevant. Development was supported by supervisory and advisory teams who proposed additional points for discussion. This allowed for exploration of themes in the existing literature and knowledge gaps in increasing engagement with preparedness materials.

Table 3.1 is an example question included in the topic guide. It shows that consideration was made of radiation disaster related factors identified in previous literature. In this case: information seeking and preparedness.

Table 3.1. *Example question from focus group topic guide with consideration of factors identified in previous literature and TDF*

Factors from previous literature	Question (with prompts)	TDF domains addressed
Information seeking; preparedness activities	What do you think you would need to know prior to being alerted of this to help you protect yourself better? *Prompts: decision making regarding protective actions, factual information, where did the attack come from, who is/will be affected* Why would you need this information?	Memory, attention, decision processes; Knowledge

The full topic guide annotated with associated TDF domains is presented in Appendix E.

Groups were required to discuss communication strategies (*what information people might want; how they wish to receive it*), and anticipated responses to receiving communications.

Hypothetical questions were included to allow reflection upon whether certain new items of knowledge would increase or decrease message engagement or instruction adherence. This also allowed for challenging of social norms and consensus that may have developed amongst the group (the 'norming' stage; Tuckman and Jenson, 1977). For example, if consensus was that evacuation would occur regardless of sheltering instructions, I asked whether receiving information about the benefits of sheltering might alter those intentions. Examples of these hypothetical questions included:

"What if I told you that…

> *….explosion damage will not extend more than 3 to 5 miles, but radioactive material in the air will travel further?"*
>
> *….overloading of the phone network can hinder aid. Would you still try to call people?"*

Topics within the discussion guide followed a logical order in which groups discussed anticipated responses following presentation of a scenario before entering greater depth in which specific items were discussed. Where necessary and because of time restrictions, I gave priority to those items most aligned to study aims.

3.2.2.4. Procedure

An advert was emailed to the PHE public involvement mailing list in August 2017. Selected participants were sent a copy of the study information sheet. On arrival participants were asked to complete consent and demographic data forms (Appendix F).

The session was recorded using a voice recorder. Notes were taken by the facilitator and public involvement recruitment lead who was also present.

The session began with an introduction to the group and research aims. Ground rules were also outlined (e.g. try to avoid talking over others during discussion). Participants had the opportunity to ask questions and to introduce themselves to the group.

Participants were given time to read the first scenario, involving detonation of an improvised nuclear device in an urban area, before discussion. Following a midway break, the second scenario involving a nuclear power plant emergency broadcast via radio was introduced. Finally, the main points that emerged through discussion were summarised and participants were thanked for their participation.

Time was allowed for informal feedback following the group. This included thoughts on the scenarios, topic guide items and facilitation. Participants were given an evaluation form to complete and return.

Feedback was discussed with the supervisory team and reflected upon for further development of the methodology of this phase of the study.

3.2.2.5. Outcomes

The sections below summarise the key areas of feedback from public involvement participants that were used to inform revisions to the study materials.

Study Paperwork

It was noted that the proposed consent form for the main study did not make clear the exclusion criteria (being military or emergency services personnel or being aged under 18). Some participants queried whether they were eligible to take part. The information sheet was edited to reflect that in addition to these selection criteria, participants were eligible if living either within a 50-mile radius of a nuclear power plant or within a large city.

Time-keeping

The focus group ran for two hours including a 15-minute break. The group moved through discussion points at a good pace allowing time for all to contribute. This was echoed in feedback.

Scenarios

Participants had some difficulty expressing their initial thoughts following the first (nuclear explosion) scenario. Feedback suggested that the scenario gave inadequate context, and so anticipating a reaction was difficult. For example, participants asked whether they had been warned in advance or had made preparations.

The second scenario (nuclear facility leak) was not effective. Participants commented that the scenario was not realistic, that it read like "*a joke*" or Wellesian "*radio play"*. Confusion was also expressed regarding the distance participants were to imagine they were from the site at the time the scenario occurred. The term '*local radio'* was used in the scenario and so it was assumed that the nuclear station in question was local to them, whereas others knew the location of Hinkley Point and assumed themselves to be at a greater distance.

In feedback the group expressed differences in how they would wish to receive information for each scenario and that their distance from the incident was a factor in their behavioural response. However, responses during the focus group discussion itself did not mirror this and no difference in response was expressed. Importantly, no different needs or requirements for pre-incident information were proposed between the two scenarios.

3.2.2.6. Discussion

The public involvement group supported many decisions made regarding study materials and design. Participants commented that the topic guide content allowed for flowing discussion and it was felt that including a scenario provided a constant reference and context for discussion. However, several areas for improvement were noted.

Changes made following feedback and reflection

I felt that some realism was lost by including too much information (such as windows breaking) in the improvised nuclear device detonation scenario. In fact, the experience would undoubtedly be different for everyone involved. To not influence responses the scenario was made less specific in its description, instead allowing participants to 'fill in the blanks'.

In practice the second half of the session (in which scenario 2 was presented) was used as an opportunity to probe aspects of the topic guide not covered during the first. Little value was added by repeating the same discussion for both scenarios, but upon reflection, participants acknowledged some differences in information needs and anticipated response between the two. My reflection was that there would be some benefit in keeping both scenarios, but not in the way I had originally planned. I therefore revised the group format in the following ways:

a. The improvised nuclear device detonation scenario would remain the central basis for discussion. The nuclear power plant leak scenario was no longer presented in its own right, instead being incorporated as a topic guide item: it would be asked during discussion whether a radiation leak would warrant differences in pre-incident communications.
b. Clarity would be provided as to where participants were in geographical location to each incident occurring.
c. Discussion would not be conducted in two halves, separated by two scenarios, a method which did not appear to elicit additional detail.

During facilitation, I felt that the topic guide was too dense to be meaningfully followed whilst also giving full attention to discussion. To ensure all items were given adequate time in the main study, I reduced it to key headings and a small number of prompts. This had the benefit of ensuring moderation was not prescriptive, instead letting data be elicited organically.

3.3. Main Study

3.3.1. Methods

3.3.1.1. Design

Eight focus groups received variations of the same scenario to discuss and were asked to consider them whilst discussing information needs.

3.3.1.1.1. Evolution to variations of one scenario

As previously mentioned, following discussion with my advisory team and public involvement group, focus groups received one scenario with slight variations depending on whether they were London residents or residing near to Hinkley Point nuclear plant. Variations of the scenario are presented in Appendix D. In brief, these included witnessing a resultant mushroom cloud rising or hearing of an attack on a city location over the radio.

3.3.1.1.1. Topic guide

The modified topic guide was used, as detailed in Public Involvement above.

3.3.1.2. Participants

I intended to recruit eight groups, with six to eight participants per group. This allowed for drop-outs whilst maintaining reasonably sized groups. Previous studies of this nature in the field of CBRN research have found this number to be sufficient in reaching data saturation (the point at which no new data is discovered) (e.g. Castle et al., 2010). This number was also achievable given budgetary constraints for participant compensation and transcription.

The study population was the general public. Members of the military, healthcare workers and emergency response staff were excluded to minimise prior knowledge or experience of CBRN-related preparation, communication and response within groups.

Additional inclusion criteria related to location of residency. Participants were drawn from only those living within 50km of Hinkley Point or within a city location; London was selected as being arguably the city most likely to be targeted in a deliberate nuclear attack due to its symbolic value and it being a centre for vital infrastructure such as government, telecommunications and finance. This study was initially designed to split participants into two sets of groups based on their area of residence and to compare outcomes of these groups. However, due to confounding variables between these groups this was deemed to not be possible and so results are presented as one set of focus groups.

The primary recruitment source was online social media networks, specifically Facebook. Local, quasi-private, community pages (‘*Bridgwater Matters,’ ‘Minehead Conversation Group,’ ‘Taunton Somerset UK News and Events’*; *‘Tower Hamlets Mums,’ ‘Love Barnet’* were targeted. Additional recruitment advertisements were placed on the community website Gumtree.com. To recruit on Facebook pages, administrators (‘gatekeepers’) were contacted directly for permission.

A further source of recruitment (callforparticipants.com) was used after an initially slow response from London residents. Callforparticipants.com is an open platform through which research studies can be advertised. Distribution of the study advertisement was successful and supplemented the participant sample to the desired number. An opt-in method of recruitment was used, with £40 in the form of a bank transfer or high street vouchers offered as compensation. A full list of online recruitment resources is given in Appendix G.

3.3.1.3. Procedure

An e-mail address was provided with the advertisement inviting interested individuals to make contact. Potential participants received the study information sheet and a demographic data profile form (Appendix F) to complete and return. An online recruitment page was also created (Typeform™). This contained the information sheet and demographic form. Hard copies of the information sheet were provided upon arrival at the group. Consent was recorded on paper on arrival at the focus group or online via the recruitment page. The consent form is presented in Appendix F.

Respondents living near to Hinkley Point were geographically clustered around two locations: Minehead and Bridgwater/Taunton. Groups took place at a location convenient for the greatest number to minimise drop-out. One group was conducted in Minehead and three in Bridgwater in village/community halls. Focus groups for London residents took place at King’s College London’s Waterloo campus. Potential participants were matched to a day and time based on preferences where possible.

Following distribution of the information sheet and completion of consent forms, rules for conduct in a focus group were read aloud, as were my role as facilitator and reiteration of the groups aims. Participants were then asked to introduce themselves to the group.

Groups then began with a short scenario, followed by guided discussion through the points in the topic guide. Towards the end of the session, participants were asked in turn whether anything discussed during the group was particularly memorable to them and why this was.

Sessions were recorded using voice recorders. Recording began once participants finished reading the scenario. Recordings were transferred to an encrypted memory stick for storage and sent away for transcription. Notes were taken to record aspects of discussion central to the aims of the group and for reference to prompt discussion where needed.

After thanking participants for taking part, signposting to more information regarding radiation and its effects was offered. Although many expressed an intention to go away and read more, none accepted these links.

3.3.1.4. Analysis

Sampling was felt to have been successful when data saturation, or the occurrence of no new information within groups, occurred.

A 'framework' approach to analysis was adopted (Ritchie and Spencer, 1994, as cited in Ritchie et al., 2014). Following familiarisation with the raw data, this method involved a process of indexing and sorting data during which a list of topics was generated. This enabled an initial thematic framework, or a hierarchy of emergent themes and themes taken from the research question (a priori) to be formed that were grounded in the data. Theme headings were formed at this stage, these were *Preparatory knowledge and actions; Responses to scenarios (Actions and behaviours); Pre-incident communications; Message content; Method of information distribution; Information sources* and; *Anticipated adherence*.

These descriptive themes (and sub-themes) were coded to provide signposting to cross-sectional (applying across transcripts) and non-cross-sectional (cases specific to that group) data. From this, a framework was further developed that was formed of thematic matrices wherein groups were allocated a row and themes allocated columns. Data extracts were reviewed at this stage to check accuracy of coding.

The matrix-based format used in framework analysis allowed for a summary and display of data which can be used to move between levels of abstraction where interwoven themes are present, as was the case in this study. It was important to build 'conceptual clarity' (Ritchie et al., 2014): a clear definition of responses to include in each independent category, within the framework to avoid overlap or omission of vital data. This allowed for identification of links in the data. This approach, which Glaser and Strauss (1965) term 'substantive' was deemed suitable as it captured representations of the participants' social worlds, feelings and perceptions. This process of interpretation of the data also allowed for identification of superordinate, or motivational, themes which provide some explanation for behaviour.

The Framework approach is used increasingly in healthcare research. For example, Ward et al. (2013) in a study of experiences amongst nurses, comment on its transparency, provision of an audit trail and accessibility to researchers of diverse disciplines. Parkinson et al. (2016) used this approach to analyse data from interviews conducted with young people regarding their experiences of depression, due to its flexibility in using a priori and emergent data in development of the analytic framework and its ease in managing large data sets.

I undertook the coding of transcripts, samples of which were checked by the supervisory team. This step was completed using MS Word before coded transcripts were imported to NVIVO 10 (QSR) software for indexing and sorting of data. Labels used for coding were a combination of ‘a priori’ (taken from themes identified during literature review) and ‘emergent’ (grounded in the data) concepts. Coding was conducted ‘in vivo’ (from terms used by participants) where appropriate.

A Framework matrix constructed at the data abstraction stage is included as Appendix H.

3.3.1.5. Ethical approval

Ethical approval for the focus group stage of this study was granted on the April 3rd, 2017 by the PNM Research Ethics Subcommittee. REC Reference: HR-16/17-4118.

This study presented few ethical issues. However, discussions had the potential to cause upset and anxiety. Participant reactions were monitored throughout the focus groups; a strategy to check whether participants wished to continue was agreed prior to undertaking groups but at no time did it appear necessary. Participants were also reminded of their right to withdraw and offered links to further information and sources of support.

3.4. Results

A total of 43 participants took part. Ages ranged from 18 to 74. More women took part (N=28 overall). London-based participants were: white British (N=33); black African (N=3); mixed/multiple ethnicity (N=1); Pakistani (N=2); Bangladeshi (N=1) and; Chinese (N=3). Eight participants had dependent children. See Table 3.2 for a summary of group demographics.

Table 3.2. *Summary of focus group demographic profiles*

		% of participants (N)
Gender	Male	35 (15)
	Female	65 (28)
Age range	18-24	21 (9)
	25-44	42 (18)
	45-64	21 (9)
	65-74	16 (7)
	75+	0 (0)
Employment status	Full time employment	35 (15)
	Part time employment	26 (11)
	Student	9 (4)
	Retired	12 (5)
	Voluntary employment	5 (2)
	Unemployed	9 (4)
	Prefer not to say	5 (2)
Ethnicity	White British	77 (33)
	Black African	7 (3)
	Any other mixed / multiple ethnic background	2 (1)
	Pakistani	5 (2)
	Bangladeshi	2 (1)
	Chinese	7 (3)
Education	Completed school	21 (9)
	College level qualification	32 (14)
	Degree level qualification	30 (13)
	Higher than degree level	16 (7)
	Did not attend school	0 (0)
Marital status	Married	30 (13)
	Unmarried, cohabiting	19 (8)
	Same-sex civil partnership	0 (0)
	Divorced	7 (3)
	Separated	0 (0)
	Widowed	0 (0)
	Single	42 (18)
	Prefer not to say	2 (1)
Dependent Children?	Yes	19 (8)
	No	81 (35)
If yes, do your children live with you?	Yes	12 (5)
	No	2 (1)
	1 or more do	5 (2)
If yes, are your children school aged?	Yes	7 (3)
	No	2 (1)
	1 or more are	7 (3)

3.4.1. Preparatory knowledge and actions

Groups expressed a belief that authorities have protections in place (without suggesting what these are) and that information would be made available when needed. Believing that authorities have protections in place was suggested to relieve anxiety.

Participants also expressed knowledge of nuclear radiation protective measures that had come from movies and that, without contrary information, actions observed in fictionalised accounts would be followed.

> *"The government could do that thing where they get all the police with their big microphones, be like, this what's happening (sp), do this, and then just like drive round the streets and give directions to people, like they do in the movies."* (Group 7; lines 674-677)

Little fear was associated with lack of preparedness knowledge, many preferring to risk radiation exposure and death than live in a post-catastrophe society. Some suggested that knowing the current national threat level would influence their response. However, threat warnings intensifying without consequence was felt to desensitise people to threat. Most felt protective advice is only required when in a high-risk situation, whilst others suggested that reminders of risk and actions to take in unlikely events do not cause adverse effects:

> *"When you sit in an aircraft and the stewardess holds up a card. Nobody gets rushing off…saying 'oh my god you're frightening me to death'."* (Group 1, lines 863-866)

Little prior knowledge of preparedness or protective actions was expressed for nuclear emergencies by many groups.

> *"if you're seeing it on the BBC News, like hey guys, we need to start getting ready for this impending nuclear attack, then I'll be like, Christ, I don't know what to do".* (Group 5, lines 233-235)

> *"We should be much better informed than we are. We should be given information…on both strands…nuclear attack or terrorism or war…but in particular because we live near a nuclear power station and we're not., it's a low-density population. But I think we should matter"* (Group 1, lines 1096-1101)

Participants living near to Hinkley Point had some knowledge of stable iodine, including a belief in it being effective at certain radiuses and that there are likely now to be better methods of protection. Several participants had received stable iodine from various sources in the area including pharmacies. These recipients felt that the information included with stable iodine, such as relating to side-effects, was inadequate.

> *"How can taking a pill help against nuclear fallout? Explain how it helps, why does it help, because otherwise I don't believe it. And I don't care who is the expert that's telling me that in my mind that doesn't make sense"* (Group 4; lines 775-780)

Based on their personal experience of (non-nuclear) disasters, some felt that the public are increasingly responsible for their own protection (once educated in protective methods). However, few reported having researched preparatory advice.

3.4.2. Responses to scenarios

For some participants, their immediate response was influenced by their recall of, and expectations from previous disasters. Experience of a communications outage during the 7 July London bombings and inability to obtain information during bush fires were recalled. Whilst an earthquake survivor expressed increased need for preparedness, people with experience of other disasters suggested a decreased desire to change behaviour.

> *"I think I'm happier just being oblivious to it, I honestly do. I think, I've gone three decades of feeling perfectly safe and secure, and I don't want that to change"* (Group 4; lines 696-697)

This was due to having reinforced beliefs of authorities having undertaken protective planning but also that the unpredictability of disasters reduces the effectiveness of preparedness planning. The Grenfell Tower disaster was cited as an example of protective actions in the event (evacuation) not being possible. Many recalled their own emotional response to disasters, expecting that they would panic given the present scenario.

Knowledge of past nuclear disasters and comparison to the presented scenario was a second key influence on response. Some considered the scenario to lack realism and not meet expectations, citing images of Hiroshima and Nagasaki and depictions from movies. One comment was that witnessing the detonation flash made survival impossible.

3.4.2.1. Actions and behaviours

Anticipated behaviour varied widely. Protective actions were felt to be largely ineffective in the attack scenario and somewhat effective in a nuclear power plant leak . Groups living in its vicinity, would close windows and doors (to keep pets safe) or self-evacuate by car (to keep children safe) if Hinkley Point were to leak. In an attack on London, groups residing in that location would shelter (at home, in local buildings with easy access such as pubs or churches, in high-rise buildings, or underground) believing the streets too dangerous, or would self-evacuate despite believing that exposure would result in death. It was anticipated that others would panic, behave irrationally, or react violently if without information.

Emotional response Fatalistic attitudes were evident in all groups, particularly toward the London scenario:

> *"I wouldn't know what to do so I can't do anything, so well, I'm not going to worry about it."* (Group 5, lines 176-177)
>
> Participant 1: *"In the event of a situation like this, it's not something that we can do anything about in the first place. Even if it comes over the news, dear Christ, somebody's launched a nuclear missile and we don't know where it's going to hit, it could be anywhere within…"*
>
> Participant 2: *"…This area, what good is that? Because anybody within the thousand-mile radius of where it could land…"*
>
> Participant 3: *"…stick your head between your legs and kiss your ass goodbye!"* (Group 2, lines 388-410)

Though others expressed less concern towards the London attack scenario:

> *"We feel so far removed from London here".* (Group 4; lines 77-78)

In some, denial and dissociation manifested in some staying indoors and "*ignoring"* the incident.

Information seeking Despite believing communication lines would be overwhelmed, many reported that they would attempt to contact emergency services, particularly if directly affected such as by injury to themselves or family members. Participants from all groups would attempt to contact loved ones in the attack scenario While some would physically seek out loved ones.

Information seeking in the event would be for corroboration: clarifying the nature of the event, informing others or checking on safety; gauging severity, spread and scale (distance, personal effect and whether the incident was an isolated or on-going emergency) and; seeking advice on what actions to take (food and water safety, local contact, evacuation or decontamination requirements). Related to this were questions such as evacuation destinations and means, shelter locations, when stable iodine should be used and how families can be protected if not together (can children be collected?). A desire was expressed for two to three simple actions to be communicated in the event, even if appearing obvious, and for honesty if protective actions would not be helpful. This included a desire to know what actions authorities were taking.

> *"Am I going to be affected? Would I need to evacuate straight away? Would I need to shelter? I don't think the authorities would necessarily know that at that time…So I think it would be more important to be saying, these are the ways we will contact you and let you know how to proceed"* (Group 4; lines 626-631)

3.4.3. Pre-incident communications

Attitudes varied as to whether pre-incident communications for nuclear emergency preparedness were wanted or required. Reasons for not believing them necessary included: a necessity for secrecy, fatalism, 'blissful' ignorance, avoidance of worry, inability to predict the nature of a nuclear catastrophe, lack of interest and concerns about the potential impact on house price. Some remarked that excessive pre-planning is a barrier to exercising common sense in the event. One participant cited having received pre-incident information for CBRN protection overseas and subsequently feeling less safe.

> *"…we were like…it's like an April Fool's-type joke, it was just so silly. But, some families felt that they wanted to come back to the UK. The wives wanted to pick up their children and get on the next flight home, so it does influence people."* (Group 4; lines 541-546)

Attitudes towards pre-incident communications were mixed. Benefits expressed included: a desire for self- and child protection; mitigating the anticipated inability of people to take on new information during a catastrophe and; as means to avoid erratic or dangerous behaviour in others.

Some also suggested that pre-incident communications need not be nuclear specific but instead should advise actions applicable to many scenarios, including personal emergencies such as acid attacks.

> *"If they just said, 'if this happens, do this'. I wouldn't trust it. If they perhaps gave you a range of possibilities … I would have more faith in it, I think"* (Group 1, lines 436-440)

> *"There are so many different things to be aware of these days…like acid attack - water; radiation - water. So, I think knowing what to do for different types of experiences …you can't predict what is, where things are going to go"* (Group 5, lines 370-375)

However, some also made comparison to past nuclear preparedness campaigns in which messages were felt to be diluted when communicated together with non-nuclear related advice.

It was generally felt that pre-incident communications would not be read: literature was compared to free newspapers and *Brexit* newsletters, while SMS-based messages were likely to be considered bogus and ignored. Comparison was made to pre-flight information, elements of which would be ignored (e.g. protecting oneself before helping children) or forgotten, and to advice about house fires in which safety advice is "*logical, makes 100% sense"*, is not fear-inducing and has repeatedly been shown to be effective when required. It was also felt that honest pre-incident information would not be made public to prevent panic and distress.

> *"I've lived here for 30 years and suddenly I'm getting this information through, it would ring alarm bells. Why do you suddenly care if I've got iodine or not?"* (Group 3, lines 114-116)

Participants had expectations that a warning would be sent via SMS prior to a known attack. However, a suspicion was raised that the government might not advise members of the public in the event of a nuclear attack.

> *"They didn't teach sailors how to swim because they knew they would drown quicker and they wouldn't suffer so much. So, I think we're along those lines."* (Group 1, lines 372-375)

Participants also expected the situation to get worse more quickly than communications could keep up with. Many noted that common communication channels may not work in such an event. However, for those who felt that communication channels would remain available, this rendered pre-incident communications redundant.

3.4.3.1. Message content

When discussing what content preparedness messages should contain, a range of options were mentioned.

Actions to take Groups felt that a range of actions tailored to different scenarios would increase faith in information. This would increase a belief that the needs of the public were considered in disaster planning, specifically; protections for pets, what to do if injured and how to help others. Specific self-protection actions were favoured, attached to stages of a visual warning system. Some also appeared to prefer to be educated as to types of radiation and how they might be affected. What to have prepared to take, where to evacuate, planned evacuation procedures and how and where to shelter were other information needs shared by all. One participant who had received pre-CBRN preparedness messaging whilst living in a warzone felt it ineffective as it was not personalised to their circumstances:

> *"They were saying things like, seal up the letterboxes but we had chimneys, and nothing was said about the chimney. So it seem(ed) so stupid."* (Group 4; lines 535-537)

Stable iodine Participants living close to Hinkley Point were most interested in stable iodine, wanting information on when to use it, why it helps and reassurance that it will not cause further problems.

Event specific Groups wished to know how to recognise symptoms of radiation poisoning, what "*removes*" radiation and where does it go. Worst and best-case scenarios were desired to reassure that actions are appropriate.

> *"I'd be more worried of going out because obviously radiation is going to get you more. I would really only want to evacuate if that was the worst-case scenario."* (Group 8, lines 591-593)

Some groups expressed additional information needs including whether protective clothing such as HAZMAT suits would be available and personal accounts of radiation survivors (e.g. what they did to survive).

How to present information Groups felt that people would not read information beginning "*in the event of (nuclear power plant) leakage…"* but instead "*if you hear X warning take stable iodine (or) go to ….*"

> *"You have to think about morale…we're probably statistically pretty safe (but) the inference is that if they put this information out there…we suddenly think it is going to happen. It makes us more worried…we don't need to know now, but if anything did happen we'd want to know pretty quickly what to do and what they are going to do."* (Group 2, lines 379-395)

Others suggested that "*three things to do in the event of a nuclear disaster*" (Group 8, part 2; line 115) would be read, particularly if relevant to different scenarios and including demonstrations such as online videos or on television in which protection methods are tested. Explanation as to why actions are advised, can manage fear and expectations.

It was considered that factual information (not "*preachy"*) enables the public to make informed choices. This should be brief, using visuals, bullet points, logos or catchphrases.

Groups felt that campaigns should be nationwide and not localised. A further suggestion was that information distributed to homes should also be specific for the type of house or building.

Groups also expressed a desire to know government plans and what an emergency alarm would sound like.

> *"We should know, because it takes a lot of anxiety away from people knowing things like that, kind of, helps with a bit of the worry that at least you know that if the worst-case scenario were to happen that there is something in place to, kind of, help"* (Group 3, lines 277-282)

3.4.3.2. Method of information distribution

No clear preference emerged as to distribution method, however groups preferred for information to be "*drip fed"* into society's consciousness, being less alarming and more effective than an information campaign; "*explosions"* of information being difficult to deal with. Specifically, information and protective training (e.g. emergency drills) should be embedded in institutions:

> *"…to really change the way people are educated you get it in schools, you get it in your Cubs and your Brownies, get your nuclear awareness badge, you know. That's how you educate people."* (Group 8, lines 304-307)

Leaflet / Letter A personalised letter informing recipients that a leaflet is coming would buffer communications being too alarming or assumed junk-mail. However, it was considered that there are not enough non-internet users to justify a postal campaign.

Media Groups expressed no desire to watch televised news items regarding nuclear radiation protection and preparedness. Preferences were expressed for radio discussion and the BBC news app.

Internet / Social Media Videos on nuclear authority websites were considered accessible before and during an emergency. Social media was felt to be open to disinformation but preferable for some as a way to raise awareness that can then be followed up using more reliable sources. This preference was attributed to online groups often sharing demographics; for example, information shared on "*mums groups*" would be read by other mums.

> *"I'm a mother of young children, so a lot of my social media groups and people I talk to on social media will be the same as me really. I think people can sometimes overreact (on social media). Social media influences people when you're talking about evacuations or sheltering"* (Group 4, lines 387-396)

3.4.3.3. Information sources

No clear preference for information source emerged. Instead, groups expressed a need to relate to the source. For example, qualities necessary for delivering information included "*humour*" and what was perceived as "*honesty"*.

Participants felt that information should come directly from the source, not via a spokesperson. Having a celebrity putting their name to a campaign was felt irritating and "*soapboxing"*. Direct sources were defined as expert organisations with "*hands on experience"* and public safety as a priority. Groups preferred information to come from a local contact with a channel to an official source or any direct source but specifically MI5 or MI6, the London Mayor, national government, universities and the police.

Importantly, source was considered not to matter if the advice was not felt to be sensible; believing actions to be unreasonable may, according to participants, cause the public to believe they are not real.

> *"if something doesn't seem plausible then you know it's wrong."* (Group 4; lines 539-540)

Government The Met Office Twitter account was presented as a model source and channel due to its seeming ability to "*negotiate alarmism and sensible awareness"* and because it is "*updated properly"*. Groups assumed that the government had responsibility for pre-incident communications which would be read if "*verified"*, meaning actions have been approved by a specialist source (e.g. the Home Office verified by a nuclear watchdog).

Specific individuals within Government split opinion: for example, the Mayor of London was considered a direct source with knowledge of national and local situations whilst others could not identify the current mayor.

Nuclear authorities A "*UK atomic agency"* (a term used to indicate an independent, specialist agency) or IAEA were considered preferable to EDF (the owners of Hinkley Point) or the UK government as they bypass internal politics, have appropriate expertise and no conflict of interest.

> Participant: *"Atomic Energy Authority, isn't it? Or Agency maybe. I think I would have more faith in that"*
>
> Moderator: *"So, an International Regulatory Body. Not the Home Office?"*
>
> Participant: *"No, not the Home Office. I'd read theirs, but…I would prefer an outside agency…it's an official agency with educated people that know what they're talking about, and I haven't got a bloody clue"* (Group 1, lines 718-732)

Similarly, responsibility for communication was felt to lie with nuclear authorities (alongside government). Information from Hinkley Point staff was considered likely to be accurate but would not influence instruction adherence.

Other sources British university departments and the police were perceived to be knowledgeable, and The Guardian and Al Jazeera were considered unbiased. Radio 4 split opinion for being factual, but government controlled. Due to their perceived infrequency of public communications, the MOD, WHO, GCHQ and UN were considered organisations to take seriously.

3.4.4. Anticipated adherence with instructions

Anticipated adherence with pre-incident preparedness instructions was considered reliant on a person's ability to carry out actions 'properly', assurance that personal circumstances were accounted for and adequate information being given (e.g. how far to evacuate; how long to shelter). Repetition over time was considered an influence on increased adherence. Repeated messages to be aware of unattended bags were given as an example of something now thought of differently than before:

> *"When you're used to frequently seeing these campaigns and hearing about them, it's just something that becomes embedded in you. When you have a one-off campaign, it won't really stick in. Repeatedly telling us, you learn to think, 'okay I have to take this seriously and take it on board'."* (Group 5, lines 493-500)

However, barriers to adherence existed. Belief that the aftermath of a nuclear attack would see a worsening situation, non-adherence of others (e.g. to not use mobile phones), perceived failures of past public information campaigns, detachment from the city (*"you just feel a different sort of attachment to the situation. Like you do feel very detached from a city that you've just moved to"* (Group 8, lines 410-411)) and preference for taking protective actions only in the event would reduce acceptance of pre-incident communication.

Ultimately, participants felt that the likelihood of an attack is low. However, they also felt that the perceived likelihood of an attack may rise following the distribution of preparedness communications. Furthermore, some felt that a perceived increase in terrorism had resulted in less attention being paid by the public to terror-related information and increased defiance (such as a reduced likelihood of making preparedness-related lifestyle changes):

> *"I (ride) horses and I've always been told (that I will be thrown off)…I don't dwell on it, I just keep it at the back of my mind. The sun's getting bigger and it can swallow, obviously, planets…there's always an, 'if', in life. Life's a massive, 'if'."* (Group 2, lines 360-369)

Sheltering (nuclear attack scenario) Reasons given for not sheltering-in-place if instructed to in the event of an attack were a belief that it would be better to shelter elsewhere, to seek loved ones and not knowing that sheltering was advised.

> Participant 1: *"I'd go get my daughter, so I'm not going to stay in the house. I would, if that's the only piece of information I got is to create a place inside a place, yes I'd create…I can create that den into anything I wanted, and she would stay in there with me"*
>
> Moderator: *"But the order is to shelter, the order isn't to go and get your daughter and bring her back"*
>
> Participant 1: *"Yes, I would break that order. She's worth the risk"*
>
> Participant 2: *"I wouldn't be comfortable leaving my children with somebody else because I would feel that they were better with me and I would feel that I will be able to comfort them better"* (Group 7, lines 664-680)

Some felt advice to shelter would hide an ulterior motive such as containing the spread of radiation and denial of the problem (implicitly suggesting that the emergency does not warrant drastic action).

Whilst many would adhere to sheltering-in-place instructions, one difficulty cited by many was in having no way to fix windows (described in the scenario as having been broken by the blast).

> Participant 1: *"Are we actually safe in our houses though? It would come in, wouldn't it?"*
>
> Participant 2: *"All houses are leaky, yes"*
>
> Participant 3: *"You got chimneys, you got open fires"*
>
> Participant 2: *"But better than standing outside really"* (Group 2, lines 810-814)

Sheltering following a London attack was dependent on their distance from detonation and size of the device.

Sheltering (nuclear power plant leak) Participants living close to Hinkley Point were unlikely to shelter if the plant were to leak. Some participants reported that sheltering would occur only after first leaving home to collect water and would be self-limited to 24 hours due to a shortage of food.

> *"In the case of a minor leak, like, okay, 'we want you to stay indoors for the next 24 hours just to be on the safe side'. That's fine. Nobody's going to have a problem with that, but if they turn around and say, 'you're going to have to stay indoors for two weeks' then…then you'd better have a way of feeding and watering me while I'm staying indoors. You were the ones who knew what was going on"* (Group 2, lines 704-707)

Reasons for sheltering or not sheltering Other reasons for sheltering non-adherence were witnessing others self-evacuate and fear of being attacked by their dog(s) if left without food. Practical concerns were expressed such as the difficulty of containing young children. Groups agreed that they would not shelter at work, though student participants suggested colleges to be shelters.

Instinct emerged as a more powerful influencer than historical reports for sheltering adherence: groups were informed that people who self-evacuated following the Fukushima incident exposed themselves unnecessarily to radiation. This did not change their intentions:

> *"Sometimes people follow their instincts so sometimes they don't follow instructions because they don't think that's what's best for them…simply you know what's best for yourself."* (Group 5, lines 189-192)

There was a lack of clarity expressed regarding water contamination and the safest length of time for sheltering. One participant had experienced a situation in which sheltering-in-place was carried out and stated that effective sheltering was not possible. Others suggested sheltering meant suffering for longer, feeling trapped. It was suggested that an important distinction in communications is in clarifying the difference between sheltering and simply not evacuating; understanding this difference would potentially influence adherence. This was echoed in urban groups who were largely unaware of how to shelter effectively.

Evacuation (nuclear attack scenario) Evacuation was considered a last resort measure in London-based participants and that "*by this time it may be too late anyway"*. Also, transport infrastructure would be overburdened and others too panicked to make evacuation possible.

> Moderator: *"'You have to evacuate immediately'; what do you think your reaction to that might be?"*
>
> Participant 1: *"Panic. It's impossible to get outside of London"* (Group 5, lines 25-27)

Evacuation advice might be adhered to, dependent upon where and how far, but self-evacuation was unlikely.

> Moderator: *"If there was a message then to evacuate?"*
>
> Participant 1: *"Yes, we couldn't"*
>
> Participant 2: *"I think it would depend on where you live… If you're smack in the middle of (town), not much of a chance. Because the infrastructure's so bad"*
>
> Participant 3: *"People will be loathe to, because they're going to leave all their possessions, when it turns out to be a false alarm and you come back, and you've been looted…"*
>
> Participant 4: *"Weekday 10 am, I'm going to go and get my daughter, she's at school, that's what I'm going to do"* (Group 3, lines 350-378)

Evacuation (nuclear power plant leak) Participants living close to Hinkley Point preferred evacuation (if given direction), particularly those with children. The decision to evacuate would be influenced by social media talk, wind direction and what they could bring. Reasons for not evacuating included care for pets, fear of looting and desire to help others. Concerns remained regarding ability to evacuate due to population and transport issues. Some maintained that they would not leave.

Reasons for evacuating or not evacuating Other determinants of evacuation adherence were reassurance that evacuation is the safest option, ability to reconnect with loved ones and inability to find a better shelter.

> *"I might decide 'well who do I want to be with in case this is the end of the world?' and meet up with them. And it might not be a case of evacuating I think for me if it gets to that point. If they're just saying evacuate and they're not telling you where, there's no decent information, I think the more important thing for me is just be with the right people."* (Group 8, lines 461-465)

Stable iodine Groups felt that taking stable iodine in a small-scale event, if they had information about side-effects and if it was guaranteed to help children, was worthwhile. However, in a catastrophic event, it was felt there is little benefit in taking it.

3.5. Discussion

I found evidence for specific facilitators and barriers to adherence with preparedness recommendations and information preferences relating to radiation disaster threats. The results of this study build upon what is already known about preferences for pre-nuclear communications and present some novel findings. The central points of contribution are:

- For message content, a range of advice is desired;
- By way of distribution, there is a preference for 'drip feeding' information in slower time than a one-off campaign;
- There is a desire to be able to relate to the information source, with qualities of the source encompassing factors of trust present in the previous literature, however the source was considered unimportant if the advice given is not considered effective;
- Regarding behaviour, sheltering was not preferred over desire to be with loved ones in an emergency;
- Individual's perception of risk was considered an influence on adherence and on acceptance of pre-incident communications which are desired only when the threat is heightened, and;
- Where there is felt to be low efficacy in carrying out recommended countermeasures, fatalistic attitudes emerged. Evidence was required for the effectiveness of actions.

These outcomes are expanded upon below.

3.5.1. Key findings

Four points of consensus were reached by the focus groups.

First, regarding content, a range of advice for varying radiation-disaster situations was desired. In the review in Chapter 2 no advice about specific actions was identified other than information about the length of time to shelter (Guterbock et al., 2010) or about protective actions tailored to the individual's distance from the incident (Rogers et al., 2013). Participants in the present study requested a broader range of information, including how and where to shelter, evacuation procedures, how they might be affected by radiation, how to help injured others and protections for pets.

Second, for message distribution, participants stated that they felt that information that is drip fed into society's consciousness or embedded in institutions, rather than presented as a sudden preparedness campaign is more likely to be impactful. This was not present in studies included in the review where traditional media (e.g. Becker, 2004; Vyncke et al., 2016) and the internet (e.g. Guterbock et al., 2010; Williams et al., 2005) were commonly mentioned. Though the use of multiple sources does correspond between both my focus groups, as participants suggested varying preferences, and the review outcomes.

Third, participants wanted to be able to relate to the information source, though the source was considered unimportant if advice given did not appear to be sensible. Whilst studies included in the review often specified preferences for particular information sources regardless of reason, one study (Bass et al., 2015) specified that young males would seek out their peers for information while another (Rogers et al., 2013) found there to be criticisms of communications that provided recommendations without explanation. The lack of consensus as to a preferred source appears consistent with much of the literature around disaster information sources. While some preference for a 'direct source' with 'hands on experience' of public safety initiatives emerged, this too is not always supported by recent literature. Latre et al. (2017) for example found a lack of credibility to be found for nuclear emergency communicators among the public following the Chernobyl disaster. While the nuclear industry as a whole were found to be competent, they were perceived to lack in trustworthiness. Lemyre and colleagues (2006) found, in a study of attitudes among the Canadian public, that the media were most often referred to for credible information whereas politicians and government were not. This perhaps supports the finding of some groups who suggested a local contact (which might include local media) with channels to official sources. This issue of credibility is vital when considering the prominent finding in the present study that source was considered unimportant if their advice was not considered feasible, a finding likely to influence perception of credibility in sources. This is important as numerous studies have shown perceived credibility to influence acceptance of information (e.g. Renn and Levine, 1991). This also does not provide direct support for the finding that participants felt a need to relate to the information source. Incorporating factors commonly found central to determining trust and credibility for information sources among the public, Renn and Levine propose five key attributes: competence; objectivity; fairness; consistency, and; faith (goodwill). Covello (2003) furthers this by attaching these factors to determinants of credibility: competence corresponding with knowledge and expertise; objectivity and fairness with openness and honesty and; consistency and faith with concern for others. Perhaps based on the outcomes of these groups, being able to relate to the source is a further addition to this set of trust and credibility determinants?

Fourth, sheltering-in-place was generally not a preferred protective action for groups due to a repeated desire to be with loved ones. Sheltering-in-place may not be adhered to as participants also expressed disbelief that their own homes are an effective shelter and to lacking resources to do so. Studies included in the review (Becker, 2004; Guterbock et al., 2010; Lasker, 2004; Malešič et al., 2015; Nyaku et al., 2014; Van Bladel et al., 2000; Williams et al., 2005) also found prioritisation in collection of children to be a reason for non-adherence. Those who perceived sheltering recommendations to be counterintuitive were also less likely to shelter (Bass et al., 2015; Oak Ridge, 2011; Rogers et al., 2013).

3.5.1.1. Motivational (Superordinate) Themes

Beyond the outcomes detailed above, some overarching issues appeared to be repeatedly discussed throughout the focus groups: *risk perception; normalisation of information; efficacy,* and *trust.*

3.5.1.2. Risk Perception

Risk was frequently raised within groups. Participants variously reported that their perception of risk is an influence on the reception of pre-incident information and on subsequent adherence to recommended actions. For example, groups largely felt that protective information was only necessary when there was imminent threat or after an attack actually occurs. Participants who perceived there to be a high likelihood of a nuclear attack occurring cited global flashpoints such as North Korea and felt an attack on London would affect the entire country. Others felt removed from this type of threat. Low risk perception individuals included those more aware of nuclear power plant safety measures. These same participants expressed a need "*to not fear radiation*" and expressed views suggesting themselves to be avoidant of preparedness information. This is somewhat consistent with previous findings that risk perception influences information acceptance (Perko et al., 2014), preparedness (Lee and Lemyre, 2009) and self-evacuation (Cutter and Barnes, 1982). Certainly, outcomes from these groups suggest risk perception strongly motivates adherence, certainly it was discussed as a factor more so than the influence of information received on adherence.

This may pose difficulties for future risk communications. It is difficult for pre-incident communications to address risk perception. Perhaps one answer is to develop pre-incident communication materials but to distribute them only at a time of raised threat. This would however run contrary to the suggestion from participants that distributing communications during a time of low risk could help familiarise people with information that might be later deployed, addressing uncertainty around the nature of nuclear attack and fostering trust in the communicating source.

Perceived likelihood was partly based on the regularity of incidents: for example, participant's perceived likelihood of fires occurring was higher than nuclear attack. Believing there to be a risk of being affected by fire was felt to stimulate increased attention to fire safety information. Perceived likelihood was also felt to depend on how official agencies act. For example, active preparedness of emergency service was considered by groups to suggest increased likelihood, spurring receptiveness to preparedness information. There may be limits to how far agency actions can increase perceived likelihood, however. During the Second World War the public considered newer weaponry on which they had received warning information to not be 'as bad' as air raids experienced from the onset of the war (Jones et al., 2006). This was considered a form of habituation, the result perhaps of improved communications, becoming accustomed to war, or both. Such habituation has been suggested more recently in response to terror threats (Galea et al., 2002; Kirschenbaum, 2006). For example, between 2007 and 2010 several terror-related incidents were reported by Australian media: surveys conducted within this population at each time-point found a significant increase in perceived likelihood of terrorism occurring, but a significant fall in concern (Stevens et al., 2011). This group was also more willing to evacuate during a terror-event. Stevens concluded that a return to 'baseline' arousal following exposure to terror-related stressors illustrates community resilience even in populations with limited exposure.

Little need to prepare was expressed towards a London attack despite mixed thoughts on likelihood. Here, fatalistic attitudes determined low perceived need for preparedness. This suggests that perceived likelihood alone is not enough to change behaviour. Two surveys examining correlations between personal predictive factors and terror threat perception (Goodwin et al. 2005) found London residents to perceive a lower likelihood of attack than rural residents. This was attributed to cognitive dissonance (choosing to live in what is considered a high-risk area whilst also wishing to remain safe). In this case, the question exists as to whether the forms of habituation perhaps observed here (that of living in high-risk areas) are adaptive or maladaptive in the context of preparedness.

3.5.1.3. Normalisation of Information

Another concept addressable by communication is that of information normalisation. This is interpreted based on study outcomes as the feeling that sudden distribution of a nuclear emergency preparedness campaign would cause fear and suspicion whereas "*drip feeding"* information to the public was a preferred method.

The finding that normalisation was seen as a positive step by focus group participants is an outcome not present in earlier studies of nuclear attack preparedness. In practice some groups suggested that normalisation might require nuclear preparedness to be embedded in schools. Whether, as some group members suggested, this would cause high levels of anxiety is uncertain. However, it is notable that other forms of emergency preparedness are tolerated well by children, including fire safety and school shooter lock-down drills wherein information normalising has realigned expectations towards the potential event and recommended actions.

3.5.1.4. Efficacy

Efficacy is defined here in terms of self-efficacy (belief in one's ability to succeed in certain situations and the influence of that belief on subsequent motivation; Bandura, 1993) and efficacy of the instructions themselves (whether one believes actions to be effective).

Efficacy was found to be important as low efficacy was associated with fatalistic attitudes, subsequently reducing engagement with communications. For example, despite evacuation being considered the only effective survival method in the presented scenario, it was also felt impossible by groups given location constraints. Efficacy appeared here to be linked to risk perception in that participants considered there to be a trade-off between the difficulty that they expect to be present in undertaking protective actions and changes in lifestyle that this effort would require against the relative risk of harm that they perceive.

An important feature of efficacy in terms of nuclear preparedness is the reoccurring desire expressed amongst groups for evidence for the effectiveness of specific actions. At least one study of CBRN preparedness information has shown a link between increased confidence in the reliability of protective information and evidence of effectiveness (Becker, 2004). It is also a factor in the social-cognitive model of communication (Lee and Lemyre, 2009) as a pre-requisite for engagement with information.

Interestingly, few expressed trust in authorities to provide reliable information about effective countermeasures. Where protective information has been given, such as Duck and Cover, instructions were perceived by groups as ineffective, fear-inducing and "*lunatic*". Groups felt that no information would be given if an attack was imminent since the effectiveness of known protections would be outweighed by the worries of officials about the likelihood of panic if information was given out. This may be more a comment on trust than efficacy, which can again be referenced in previous literature where the provision of reliable information has been found to cultivate trust (e.g. Rogers et al., 2013). Importantly, where efficacy is perceived to be low trust is reduced, but provision of information regarding efficacy can enhance trust.

As will be discussed below however, trust in this context, plays a less vital role, at least in adherence with recommendations, than risk perception and efficacy of instruction.

3.5.1.5. Trust

According to the groups, the benefits of a trusted source are clear: information is more readily received and accepted as the best available. However, it became apparent in groups that while trust matters in many circumstances, in the context of existential threat it is not as straight-forward.

Trust appeared to be related to several factors: perceived honesty in the reasons for why certain countermeasures are recommended; whether recommendations come with evidence of effectiveness; pre-conceived beliefs and experiences of a communicating source; whether full disclosure on the part of authorities occurs, and; belief in protection offered to the public against nuclear threat by authorities such as the government and military. These are similar issues to those in the literature. Individual dimensions of trust have been found to include competence, (Löfstedt, 2005), consistency, (Renn and Levine, 1991), caring, (Kasperson et al, 1992) and dedication (Covello, 1993). The Pre-event Messaging Project (Wray et al., 2006) explored elements of public trust in government which are evident in my outcomes including confidence in government preparedness (providing reassurance) and willingness to disclose information.

How important trust is in terms of convincing people to engage in preparedness or protective behaviours is complicated. The key message that came from groups' discussions of trust in the information source is that trust does not depend on what is said, rather it reflects the individual's perception as to whether the communicating source has the public's best interest at heart. Therefore, we could posit from this, coupled with the wide-range of preferred information sources expressed by groups, it is not important who the communicating source of information is, as long as they adhere to the principals of trust outlined above. This also aligns with the aspects of dedication and caring (also present in findings of the Pre-incident Messaging Project). In Earle's (2010) consensus model of trust in risk communication this concept of perceived benevolence in communicators is termed relational trust. There is then an inherent problem: how do communicators ensure that they are instinctively believed?

A further complication comes from the finding that whether a source is trusted to provide accurate information was felt by focus groups to be less important if the recipient believes that the actions recommended would be ineffective, or that the effort involved in taking such actions outweighs the perceived potential for harm. Based on discussions on the subject of trust, , there appears to be an inherent distrust of information currently available at present. It could be that these aspects interact: communicating efficacious actions improves trust, while communicating ineffective actions degrades it.

Groups added that in a situation perceived by many to be hopeless in terms of self-protection, the absence of options forces a reliance on trust. To be explicit, in considering existential threats "*you have to trust that plans are in place.*" There is little choice but to trust in some kind of protection from, as was suggested unanimously, the government. This suggests that many feel that responsibility for public protection is in the hands of others. This relates to the second concept of trust in Earle's consensus model: calculative trust. Based on past behaviour of communicating authorities and on constraints imposed on future behaviour (and perhaps perceived efficacy and effectiveness of recommended countermeasures) this relates to the amount of confidence that the public has in authorities. This perhaps also suggests that in fact there is too much trust amongst the public in the protective powers of government to the detriment of personal responsibility for preparedness.

Nonetheless, it remains the responsibility of risk-communicating authorities to present information known to be most effective in offering protection. What's more, trust cannot be ignored as a factor in nuclear preparedness communication development due to its significance in risk and crisis communication research. Individuals have been found more likely to follow the instructions of trusted sources (Shore, 2003) and trust has been found to influence actions when knowledge of risk is low (Siegrist and Cvetkovich, 2000) highlighting the potential interplay between risk perception and trust, two central influences of adherence.

In the forthcoming phases of this research it will be important to examine whether beliefs around authority or emergency service preparedness, or perceived effectiveness of recommended actions are barriers to taking preparatory actions. These outcomes provide evidence for inclusion in the final stages of this project, two online surveys.

3.5.2. Limitations

Focus groups involve refinement of what the participant wishes to express through interaction with and probing of central ideas and discussion points. Whilst important in 'attitudinal' research, a methodological limitation is the extent to which the facilitator injects themselves into discussion. Lehoux et al. (2006) feels that freedom to express views in focus group participants is influenced by the way in which initial tasks are presented (the scenario) and how participants are invited to '*break the ice*'. I would suggest that a further influence was re-orientation to ensure sufficient addressing of research questions. Groups in this study frequently returned to the subject of information reception and information seeking only in the event of a nuclear emergency; there appeared to be difficulty in maintaining focus on pre-incident communication. This is consistent with the expressed preference for information to be given only when needed. This may be a failing of the topic guide, the scenario, group facilitation or a combination. On the contrary, the scenario appeared to effectively allow participants to envisage themselves experiencing the scenario with some realism, drawing out reported information needs at that time. A different scenario might have aided focus on pre-incident communication.

It was difficult to avoid sampling bias in recruitment. Several attempts were made to correct this. Parents were relatively under-represented during recruitment so potential participants with children were prioritised for group selection. London area recruitment resulted in many students responding, most likely since the callforparticipants.com distribution list includes universities. A small number of students were selected to not weight groups heavily by this demographic.

It should also be noted that a small number of participants were known to each other, potentially eliciting a response bias. However, this did not appear to influence responses; there was disagreement between participants known to each other to an equal extent of agreement.

3.5.3. Implications for next phase

Phase one of this project used a systematic review to outline gaps in our knowledge about how to communicate with the public about a nuclear disaster. The present study has helped to fill some of these gaps and clarify areas where additional research might be beneficial.

A wide range of information preferences were expressed meaning clarity in terms of what the public feel constitutes ideal messaging has not yet been achieved, or perhaps more likely, that there is no 'ideal' in pre-incident communications for nuclear catastrophe preparedness. Amongst emerging questions is whether preparedness information is wanted during the pre-incident stage, and not solely in the event of a disaster or imminent attack. Not only is this a question of gathering further evidence regarding the timing of public communications, but also whether desire for information is a requirement in this context. This second point is of less relevance: communications in the context of health promotion maintains a focus on what the public need to know, rather than what they want to know, and communicate with the public based on this knowledge (Ratzan, 2001). However, the question of desired information is still a valid one; presenting information that we know the public want may increase the likelihood that they attend to that information. Without meeting the public's information needs there is a danger that they are lost as an audience.

Another area for further study is the role of factors potentially beyond the remit of communications (such as risk perception). It has been discussed how risk perception is important in influencing effectiveness of pre-incident communications and how public communication might, in turn, affect risk perception. Outcomes of this study suggest that those most likely to believe that pre-incident information for nuclear emergencies is needed are those who perceive that an incident is more likely, who are most concerned with harm to children and who believe it important to be prepared. Importantly though, outcomes suggest risk perception to be a stronger predictor of adherence in those attending to information than the actual information received.

It has been discussed how outcomes related to trust in sources does not fully support previous evidence as to the role it plays in information reception. Even so, appropriateness and preference for the sender of information is still an area that should be explored in developing effective risk communications.

3.6 Conclusion

Little desire was expressed for pre-incident communications designed to inform people how to better prepare for a nuclear incident, though while participants appeared pessimistic, there was little evidence of fatalism. This is exemplified in the perceived countermeasure efficacy among groups. For example, while opinions differed across groups as to whether pre-incident communications are necessary, there was unanimous interest in stable iodine. This suggests a conflict in some: those who express no desire to take preparedness measures (perhaps due to perceived low likelihood) but who are not dismissive of potential safety actions to be taken in the event of an incident. It may be that the key factor influencing information engagement is instruction efficacy and achievability. In the case of stable iodine, taking a pill to obtain some protection against radiation is likely to be considered more achievable and less taxing than actions such as evacuation, stockpiling food or sheltering-in-place. Many who were aware of stable iodine felt better forms of protection are likely to be available, however. It is important therefore that risk communicators remain mindful that not wanting pre-incident communications does not necessarily equate to lacking a desire for self-protection.

Unresolved questions remain, including: how important is trust; who do people trust to provide the most effective preparedness advice; and what is the importance of perceived risk and instruction efficacy? These are questions to be explored further in the following phases of this research.

Chapter 4: Survey with Members of the Public in Hawai'i Following a False Ballistic Missile Alert

The focus groups outlined in the previous chapter elicited outcomes not previously seen in the literature specific to nuclear risk communications. This includes participants expressing concerns as to the level of perceived effort involved in carrying out adequate preparedness in relation to the efficacy or effectiveness of those measures in the face of nuclear catastrophe. These groups also provided a mixed picture as to their desire for pre-incident information and their anticipated adherence to recommended protective measures. The survey that the present chapter maps out is undertaken with members of the public in Hawai'i. While this phase of data collection was not planned at the outset, the false ballistic missile alarm experienced by the Hawai'ian public presented an opportunity to collect data on actual behaviour in the face of potential nuclear catastrophe not present in the previous literature on this topic. This was therefore an important opportunity to build on the outcomes of the previous chapters with a particular focus on behavioural response to the warning.

4.1. Background

On January 13th, 2018, a Saturday, at 08.07am local time, members of the Hawai'i public received an emergency alert via SMS from the Hawai'i Emergency Management Agency (HI-EMA), a Governmental agency representing the first line of state-wide disaster response (http://dod.hawaii.gov/hiema/). This alert read:

Ballistic missile threat inbound to Hawaii, seek immediate shelter. This is not a drill.

News reports (e.g. BBC, 2018; Hennigan, 2018) and social media feeds (Reinstein, 2018) suggested that the public did not adhere to this instruction. Reported actions included leaving home to find concrete buildings or placing children in drainpipes to protect them, risking drowning or exposure to dangerous gases. Whilst some sheltered in bathtubs and manholes, others reported a "resigned acceptance" (Hennigan, 2018) or not knowing what to do. Whilst some reports existed of "hysteria" and "panicked evacuations" (BBC, 2018; Karl and Lytle, 2019), interviews conducted with around 80 residents and tourists a few days following the alert (Peterson, 2018) suggests that this was rare, finding that despite confusion, people took a more measured approach that primarily involved information seeking based on a lack of knowledge, such as not knowing shelter locations. This is exemplified by screenshots of Twitter feeds and SMS messages full of comments such as "….everyone's phones are buzzing with a warning...Info? Anyone?" and "Not sure what to do. Sirens are going off".

Fortunately, the alert had been sent in error; there was no inbound missile. An employee at HI-EMA had mistakenly selected the alert from a dropdown list of confusingly near-identical options (Wang, 2018) after failing to hear the word *exercise* during the briefing given for what was actually a practice run (Berman and Fung, 2018). HI-EMA corrected the mistake with an e-mail 18 minutes later and with a second SMS after 38 minutes (Hennigan, 2018) (see Figure 4.1).

- 8:07am: reports begin of members of the public viewing the alert on their smartphones
- Local television broadcasts are interrupted by an audio and scrolling banner alert; a civil danger warning broadcast stating:

"The US Pacific Command has detected a missile threat to Hawaii. A missile may impact on land or sea within minutes. THIS IS NOT A DRILL. If you are indoors, stay indoors. If you are outdoors, seek immediate shelter in a building. Remain indoors well away from windows. If you are driving, pull safely to the side of the road and seek shelter in a building or lay on the floor. We will announce when the threat has ended. THIS IS NOT A DRILL. Take immediate action measures."

- 8:13am: State Warning Point system used to cancel the alert (this prevents it from reaching phones that have not already received it)
- 8:20am: Official messages refuting the alert are sent out:
    - HI-EMA use social media accounts to inform the public that the original alert had been sent in error.
    - Electronic signs over major roadways used to alert drivers of the error.
- 8:45am: Second emergency alert sent, stating:

"There is no missile threat or danger to the State of Hawaii. Repeat. False Alarm."

Figure 4.1. Timeline: distribution of the ballistic missile false alert (CBS News, 2018; KITV 4, 2018; Nagourney et al., 2018)

Since threats between the US and North Korea had escalated in the preceding months, the Hawai'i ballistic missile false alert was probably the first credible activation of a nuclear attack warning system since the Second World War (Preston, 2018). Previous research into the predictors of instruction adherence in nuclear emergencies has been conducted following nuclear facility emergencies (Fukushima: e.g. Rubin et al., 2012; Three Mile Island: e.g. Prince-Embury, 1992) or has relied on hypothetical attack scenarios (e.g. Becker, 2004). The false alert in Hawai'i offers a unique opportunity to identify factors that promote adherence with protective advice in a population who have experienced the existential threat of being informed that a nuclear attack was under way.

The Hawai'ian islands are widely known to be susceptible to natural disaster: most commonly flash flooding, though the state has experienced two devastating hurricanes this century and tsunamis hit at least once every year. While not all of Hawai'i's islands homes an active volcano, earthquakes caused by volcanic activity have a wide-reaching effect and the state is affected by them on an almost constant basis. Anecdotally Hawai'ians consider themselves not to be 'preppers' (Wallis, 2018) though a number of emergency preparedness resources and guidance-producing organisations exist (e.g. HI-EMA; Pacific Disaster Center (PDC.org); Hawaii Army National Guard: Family Emergency Preparedness Plan (Hawaiiguardohana.org). It is notable that in the months prior to the false alert, Hawai'ian authorities had conducted drills using public alert systems and made disaster preparedness information available to the public in various forms, such as online and in town hall meetings (Kelkar, 2017). The threat of nuclear attack meant that over twenty town hall meetings and television advertisements to educate the Hawai'i public on preparedness for a nuclear strike were aired during late 2017 (Broder Van Dyke, 2017). In the month prior to the alert, Cold War-era emergency sirens were widely tested throughout Hawai'i, with 93% found to be working; though some residents reported not being able to hear them, and twelve mistakenly played an ambulance siren (CBS News, 2017). Hawai'i's emergency siren warning system was not formally activated during the alert period (Magin, 2018) but officials did nonetheless report some activated on Oahu (presumably locally, rather than by HI-EMA centrally) following the notification (CBS, 2018; VOA News, 2018).

Previous phases of this PhD, and additional evidence from other resources, have shown factors that might affect preparedness and response in relation to nuclear threats. For example, the systematic review (Chapter 2) suggested that the behavioural impact of a nuclear alert might be affected by communication-related variables including distrust of the information source (e.g. Bass, 2016), conflicting or inconsistent reporting (Pheby and Robinson, 1990), the perceived counter-intuitiveness of instructions (Oak Ridge, 2011) and not understanding terms such as *shelter-in-place* (Becker, 2004; Pearce et al., 2013). Some previous literature has also suggested that there are demographic differences in how information is received (e.g. Kanda, 2013i) and how it influences behaviour (e.g. Bass et al., 2016). Perhaps most consistent is the finding that people would ignore or delay self-protective actions in a nuclear emergency to be with or contact loved ones, particularly children (e.g. Nasar and Greenberg, 1984). Outcomes of focus groups with UK participants (Chapter 3) also found specific factors that might influence adherence regarding protective actions, including the perceived efficacy of recommended actions and ability to effectively carry out the action.

In a study with American participants (not Hawai'i citizens exclusively) conducted shortly after the false alert, 64% still reported having not been informed of nuclear attack preparedness recommendations despite the events in Hawai'i occurring only months before. Furthermore, most reported not thinking about what they would do if a nuclear attack occurred. In fact, 29% stated that they put little effort into preparedness despite believing the likelihood of an attack to be only slightly more unlikely than likely (Karl and Lytle, 2019). This low level of preparedness is important, given evidence that paying attention to preparedness communications not only increases knowledge but also influences how people intend to act during a genuine emergency. While many factors may influence whether people prepare for a nuclear emergency, one factor suggested by both the systematic review and focus group findings is whether people perceive that, a) a nuclear incident is unlikely, and b) even if one does occur they nonetheless trust that plans are in place via the government which will protect them. Sadly, both of these perceptions may be incorrect.

Trust is a recurring factor in the reception and acceptance of risk communication. In fact, the importance of trust in the source of communications represents perhaps the most significant discrepancy between systematic review and focus group outcomes. The review found that information acceptance during an incident was predicted by trust in the message source (Murakami et al., 2016; Perko et al., 2012), amongst other factors not related to trust. Trust in the source and checking the information with trusted others, such as family and friends (Bass et al., 2015) also tended to increase instruction adherence. Non-adherence with sheltering advice was found to be associated with low trust or confidence in community or government preparedness. UK non-governmental sources (Pearce et al., 2013) scientists (Latre et al., 2017) and the US President (Guterbock et al., 2010) were rated as being the most trustworthy sources. Least trusted were US national media and local authorities (Bass et al., 2015; Guterbock et al., 2010). The nuclear industry also appears amongst the least trusted to provide risk communication information. Trust was found to increase as a result of consistent messaging between authorities, such as expert medical advice (Rogers et al, 2013). Whilst focus groups suggested clear benefits of trusted sources providing communication, there was also a belief that trust is less important when the threat is existential. Instead, groups were consistent in their belief that the public must trust that plans are already in place for public protection, and for authorities to communicate with the public in the event. Pre-incident information was therefore seen as unnecessary for nuclear threat. Furthermore, it was felt by focus groups that trust does not influence adherence in instances where recommended actions do not appear reasonable. In this sense, it is what is being said rather than who says it that counts.

Much of the literature on how risk communications are received is concerned with the channel by which it is delivered. For example, channels that involve written communication have been found to result in the transfer of more accurate information than verbal channels (Edworthy et al., 2014). Social media is an increasingly convenient channel by which information is quickly spread. Whilst a large 2017 review of empirical studies by Rasmussen and Ihlen found a limited literature on risk communication and social media, this is a growing area of research. For example, examination of risk information and its sources found target groups to use social media during a crisis for checking in with family and friends and for “insider information”; whilst traditional media was used instead as an educational tool. The use of both channels is often influenced by convenience and personal recommendations: sole use of traditional media influenced by perceived credibility whilst negative attitudes towards social media’s more commonly perceived uses discourage its use for risk communication purposes (Austin et al., 2012). However, following the trend seen in increased social media use during a crisis (Pew, 2006) and the increases in the perceived credibility of the medium (Procopio and Procopio, 2007) Austin and colleagues (2012) showed that social media influence was greater during an emergency than information received from traditional media pre-crisis.

In addition to psychological variables playing a key role in how people respond to a nuclear alert, the situation people find themselves in when they receive emergency risk communications is also likely to be relevant. This event presented an important opportunity to gather data as to actual levels of preparedness in the public that would aid in responding to a nuclear emergency. At the most basic level, it will be easier for someone to shelter if they are already within a building than if they are outside. However, related factors may also be important, such as whether they are at work or at home at the time (Pearce et al., 2013). This is reflected in the objectives of this study.

There are limitations to undertaking a study such as this, which was unplanned at the outset of undertaking this thesis. Recruitment for this study was not budgeted for nor were established links or known reliable recruitment avenues in place. I was able to form links with academics at the University of Hawai’i who offered support in recruitment as well as education in terms of the Community-Based Participatory Research model favoured on the Islands, important historical context and previous less-than-ethical practices of non-native researchers which allowed me to approach recruitment with respect and sensitivity. Still, this study provided a population group with important historical, contextual and cultural differences to those that this research was intended to serve (the UK public) upon initial study design. The efficacy of these outcomes are also reliant on self-reporting after the event, a post-event only design and no comparison group, much of which is documented in detail in the discussion section of this chapter. Nonetheless, this event represented a unique opportunity to gather data of this kind which will no doubt inform the overall findings.

4.1.1. Study objectives

In this study a cross-sectional survey of a sample of the Hawai'i population was used, approximately nine months following the false ballistic missile alert to:

1. (aligning with the first of the project aims) identify the proportion of people who a) possess adequate materials (as defined by HI-EMA) within their home to allow them to cope with a nuclear emergency, and b) possess these materials specifically as a result of attempts to prepare for a nuclear emergency;

2. (aligning with the second of the project aims) assess the desire for pre-incident information relating to nuclear preparedness following the false alert;

3. (aligning with the first of the project aims) assess adherence to the instruction to shelter-in-place. This will be achieved via the following sub-objectives:

a. identify the prevalence of behaviours that were, a) deliberately adherent to the instruction to shelter, i.e. involving participants taking active steps to follow the guidance; and b) incidentally adherent, i.e. involving participants taking active steps to follow the guidance or else being adherent by virtue of circumstance, such as being in bed at the time;

b. Identify the proportion of people who believed the message to constitute a genuine emergency alert;

c. Assess whether the following variables were associated with adherence and preparedness outcome variables:

- by what means the message was received;
- whether participants believed it to have been a genuine message from HI-EMA;
- whether they believed an attack to be imminent;
- whether they had prepared for an emergency;

- how much preparedness information they had previously received;
- their level of trust in Hawai'i's defence capabilities;
- their perceived likelihood of a nuclear attack occurring in Hawai'i, and;
- the perceived level of effort involved in taking protective measures (such as sheltering).

Aligning with the second of the project aims, the same survey was used to gather additional data that would be of use in developing improved communications with the population, specifically:

- ways in which participants attempted to find out information as to how they could protect themselves or others;
- from which sources they had obtained preparedness information prior to receiving the warning;
- how recently had this information been received;
- whether this information was viewed as having been sufficient;
- preferred timing of communications;
- reasons for not wishing to receive pre-incident communications;
- preferred content of pre-incident communications, and;
- their ratings of trust in potential information sources.

4.2. Method

4.2.1. Design

This study was conducted using an online, cross-sectional survey sent to members of the public in Hawai'i. Theoretical Domains Framework was used to inform items for inclusion.

4.2.2. Participants

Members of the public were eligible to take part if they had been in Hawai'i on the 13th January 2018, had received the ballistic missile alert by any means including mobile phone, radio and word of mouth and were over 18 at the time of the survey.

4.2.3. Materials

An online survey was developed using Qualtrics^{XM} software. Questions were forced choice and routed so that participants were directed only to questions relevant to them and away from those not applicable to the respondent. Full survey items are shown in Appendix I.

4.2.4. Outcome variables

4.2.4.1. Preparedness

Respondents were asked to select from a list all preparedness actions they had taken prior to January 13th, 2018. Listed actions were taken from Protect and Survive (HMSO, 1980), from FEMA's most recent information sheet published in March 2018 and from the HI-EMA website (HI-EMA, 2017). Actions included: obtaining a battery powered radio and batteries; storing a 14-day supply of food and water; having a first aid kit; attending a town hall meeting on emergency preparedness; and being prepared to shelter for 72 hours. For each action that was endorsed, respondents were asked to give their reason for undertaking this action. The four possible reasons were: specifically for nuclear attack preparedness; in case of a different specific emergency such as hurricanes; for general emergency preparedness or, not for emergency preparedness purposes.

4.2.4.2. Pre-incident communication preferences

Respondents were asked whether they wished to receive pre-incident information regarding protective actions in a nuclear attack. Those who responded no were asked to elaborate. Response options included: I would be too afraid, and I don't believe I could be protected if Hawai'i was attacked.

Those who responded yes to this question were directed to a further question asking when they feel would be the best time for them to receive this information; during a period of low threat, or only when a threat is known to be imminent. This group were also asked, using an open-ended question, to detail two pieces of information they felt it would be most important to be informed of in pre-incident communications.

4.2.4.3. Adherence

Respondents were asked to report the actions they took upon receiving the initial ballistic missile alert. Response options were a combination of behaviours identified in previous disaster response literature and in news reports from the event (e.g. BBC, 2018; Peterson, 2018; Reinstein, 2018). They were: took no action; sought immediate shelter; made efforts to verify that the information was correct; made efforts to find out protective actions I could take; initiated a pre-arranged plan; left home to seek out friends or family and; got in contact with/tried to contact friends or family via social media or phone.

Participants were asked why they took the action(s) they did upon receiving the ballistic missile warning and offered eight possible response options: I felt prepared/knowledgeable as to what actions I should take; I felt unprepared/lacked knowledge as to what actions I should take; I wished to verify that the information received was accurate; I wanted to protect my family; I wanted to be with family/friends; I wanted to help others (strangers) who may have been hurt; my family/friends and I had a pre-arranged meeting place for such an emergency; I did what the warning advised me to do (regardless of whether I felt it the safest action or not); I thought my actions would protect me and, 'other' reasons.

Respondents who stated that they sought further information were asked to detail the sources of information they used or attempted to use for this purpose.

Respondents who reported taking no action were directed to a free text question asking why that was the case.

4.2.4.4. Belief in message

Respondents were asked whether, upon first hearing the original warning, they believed that it had been sent by HI-EMA. Respondents could answer: yes; not applicable - I did not hear until after it was known to be a false alarm: no - I believed the warning to be from a source other than HI-EMA; or no - I believed the warning to be a hoax. Participants who gave either of the two 'no' responses were directed to an open text question allowing them to state why they did not believe the warning to be a genuine HI-EMA message. Those who responded not applicable were redirected past that block of questions.

Respondents were also asked whether they believed that an attack was imminent. Response options were: yes – I believed that an attack was imminent and no – I believed the warning to be a hoax or a mistake or that it would come to nothing. Full frequency data for the remainder of the survey is presented in Appendix J.

4.2.5. Predictor Variables

4.2.5.1. Awareness

Two items related to being made aware of the warning. The first item asked how participants became aware of the alert. The second item asked where they were upon receiving the information. It is felt that receipt of a warning such as that which is the subject of this research would constitute a '*where were you when you first heard*….' moment and so some confidence can be retained from recall of this information despite the time that has passed.

4.2.5.2. Risk perception

To assess the perceived risk of a successful nuclear attack occurring in the future, participants were asked if they believed Hawai'i to be protected from nuclear attack by military intervention and their perceived likelihood of a nuclear attack occurring in Hawai'i during their lifetime. Unfortunately, with no reference in which the military has been called upon to defend Hawai'i from an incoming attack of this magnitude to draw from, this question is reliant upon perception of respondents. However, perception of protection from threats has been shown to influence risk perception and preparedness behaviour (Becker, 2004).

4.2.5.3. Prior information received

Respondents were asked to state the amount of general disaster preparedness information they had received prior to January 13th, 2018, and the amount of preparedness information specific to nuclear disasters that they had received. They were asked where they had received preparedness information from, when it was most recently received and whether participants felt that information received had been sufficient. Again, accuracy of reporting for these items are reliant on recall. As preparedness guidance can be received for various scenarios and situations, from vehicle breakdown to natural disaster and everything in between, it may be the overlapping recommendations can become confused in terms of source or in priming the memory of nuclear threat, previous information received may not be recalled if intended to prepare the recipient for a small-scale threat.

4.2.5.4. Perceived preparedness effort

The *perceived effort* that would be required to adequately prepare was a prominent feature in focus groups (previous chapter) in that participants expressed a belief that there is a trade-off between lifestyle changes that the effort of preparing for emergencies would require against the relative risk of harm that they perceived to be present. This resonates with disaster preparedness literature, such as actions in pre- and post-disaster relief effort being weighed against perceived disaster magnitude (He and Zhuang, 2016) and the wider health literature such as the effort-reward imbalance model (Siegrist and Li, 2016) which suggests that over-commitment (high effort) combined with low rewards is a cause of poor health such as increased stress. In this survey participants were asked to rate the perceived effort involved in carrying out individual actions listed in the earlier preparedness question with the addition of the following activities: watch preparedness videos online; be prepared to shelter (e.g. at home) for up to 72 hours; be prepared to shelter (e.g. at home) for up to 1 week; be prepared to shelter (e.g. at home) for up to 2 weeks; be prepared to leave your home to a place of shelter within your town or village and; be prepared to leave your home to a place of shelter outside of your town or village.

4.2.5.5. Trust

To identify the most trusted sources of information relating to nuclear preparedness, participants were presented with twelve sources (e.g. HI-EMA; nuclear agencies; local authorities; emergency services) and asked to rank them in order of most trusted to provide them with information about how to prepare for a nuclear emergency. It may be that participants have had no prior experience of dealing with a number of these sources; in which case aspects of trust forming identified in focus groups (previous chapter) such as belief that the organisation has the public's best interest at heart and has no competing interests and those found in the literature such as confidence in, and perceived credibility of the institution (Renn and Levine, 1991) are implied in responses.

4.2.5.6. Demographic variables

Participants were asked to state their gender, age, ethnicity, employment status and achieved level of education as of January 13th, 2018. These items were taken from the United States Census Bureau (2017).

Participants were also asked whether they had dependent children on January 13th, 2018. Response options were: no; I had a dependent child/children aged under 18 who was living with me; I had a dependent child/children aged over 18 who was living with me and; I had a dependent child/children under 18 but they did not live with me.

4.2.6. Procedure

Participants were identified and recruited with the assistance of collaborating partners at the University of Hawai'i and by commissioning a market research company based in Hawai'i to conduct a survey of their existing panel members. Participants recruited via the University were awarded course credit whilst those recruited by the market research company received a monetary reward. Other channels of participant recruitment were explored, including the patron contact list of the Kumu Kahua Theatre in Honolulu where a production about the false alert had been put on, and City and County of Honolulu Neighbourhood Commission Office online noticeboards. In practice, it was not possible to recruit via the Commission Office noticeboards. Due to very low response rates using the Theatre's contact list, participants who were recruited using this method were not included in the analysis.

A link to a survey hosted on Qualtrics^{XM} was distributed to individuals who formed part of the market research participant database. Interested individuals were able to follow this link anonymously and access an information sheet using any internet enabled device. Providing they indicated their consent by ticking the relevant consent items, they were then able to participate in the survey. The survey link was also made available to students enrolled in undergraduate courses at the University of Hawai'i via an online research participation database. The survey became available for market research participants on October 5th, 2018 (slightly under nine months following the alert) and met the required sample size after three days. It was available for University of Hawai'i students throughout November 2018.

4.2.7. Ethical Considerations

Approval for the study was granted by the King's College London Psychiatry, Nursing and Midwifery Research Ethics Subcommittee (ref: HR-17/18-7059) and the University of Hawai'i (protocol number: 2018-00712).

4.2.8. Sample size calculation

Based on a Hawai'i population of 1.42 million (World Population Review, 2018), to obtain a 95% confidence level with 5% margin of error a sample size of 385 completed responses was required according to the sample size calculator tool on surveymonkey.com.

4.2.9. Outcomes and Analysis

All responses were recorded on an Excel (Microsoft) spreadsheet. This was imported into SPSS version 25 (IBM) for statistical analysis.

Weighting was initially applied to reflect the gender distribution in the general population. However, comparison of weighted against unweighted outcomes showed negligible differences. All analyses were therefore conducted with unweighted data.

Some outcomes required re-categorisation for comparative significance testing. Where re-categorisation occurred, it is detailed below.

4.2.9.1. Preparedness

Because there is a potential difference in the factors associated with whether someone consciously engages in actions to prepare for a disaster, and whether they engage in actions that, by accident or coincidence, make them prepared (e.g. collecting camping gear), the sample was recategorized as intentional (taken for disaster preparedness reasons) or incidental (undertaken for non-disaster preparedness reasons) preparedness. Undertaking actions for general emergency preparedness, nuclear-specific preparedness and preparedness for a different type of emergency were all defined as intentional.

Scores for absolute preparedness (that is, regardless of whether it was intentional or incidental) ranged from 0 to 8 activities. For intentional preparedness, a median split was used which categorised people reporting zero to two intentional preparedness actions as having low intentional preparedness, and those reporting three to eight actions as having high intentional preparedness. Binary logistic regression was used to calculate odds ratios for the associations between intentional preparedness and demographic variables. Adjusted odds ratios were calculated (adjusted for demographic variables) for associations between intentional preparedness and the following predictor variables: prior level of disaster preparedness information received; prior level of nuclear preparedness information received; source of preparedness information; how recently was preparedness information received; perceived sufficiency of preparedness information received; belief in protection from military; low preparedness effort and; high preparedness effort (see next section). Unadjusted odds ratios are displayed in Appendix K.

4.2.9.2. Preparedness effort

Responses were rated on a ten-point scale (1 = very little to no effort involved; 10 = much more effort than I would be prepared to take). The data reduction method *principal components analysis* was used to identify if discrete groups of preparedness actions could be grouped together in terms of their perceived effort or in terms of whether participants had engaged in that action or not.

4.2.9.3. Adherence

Deliberate adherence and incidental adherence rates based on adherent (sought immediate shelter; initiated a pre-arranged plan) or non-adherent (took no action; left home/the place I was at to seek out friends or family) responses were calculated.

Incidental adherence was defined as any action that equated to adherence with the warning instruction to shelter, which included remaining at home upon receipt of the warning. Deliberately seeking shelter or initiating a pre-arranged plan were included in this definition to gain a full picture of adherence overall. In contrast, deliberate adherence was defined as simply intentional sheltering or initiation of a pre-arranged plan (that aligned with the instruction to shelter). Where participants used a free text response to provide more detail on their actions, these were also used to assess whether they were incidentally or deliberately adherent. For example, where a participant elaborated that they “stayed in bed” this was categorised as incidental adherence.

Non-adherence was defined as being outdoors upon receiving the warning and not seeking shelter or being indoors upon receiving the warning and taking action that meant sheltering did not occur, such as leaving the house.

Only the respondents who reported having received the warning before being made aware that it was sent in error were included in analyses related to adherence.

Binary logistic regression was used to test associations between adherence and demographic variables. Adjusted odds ratios (adjusted for demographic variables) were also calculated for associations between deliberate adherence and the following predictor variables: location upon receiving warning; by what means the message was received; whether the message was believed to be from HI-EMA; whether an attack was believed to be imminent; prior level of disaster preparedness information received; prior level of nuclear preparedness information received; belief in military protection from a nuclear attack; intentional preparedness and; perceived level of effort involved in sheltering for 72hrs. Unadjusted odds ratios are displayed in Appendix L.

4.2.9.4. Belief in message

Binary logistic regression was used to test associations between whether respondents believed the warning to be genuine, being deliberately adherent to protective instructions, and demographic variables. Adjusted odds ratios (adjusted for demographic variables) were also calculated for associations with the following predictor variables: location upon receiving warning; how the message was received; whether the message was believed to be from HI-EMA; prior level of disaster preparedness information received; prior level of nuclear preparedness information received; source of preparedness information; how recently informed of preparedness information; belief that preparedness information was sufficient; belief in protection from military; perceived likelihood of nuclear attack and; intentional preparedness.

4.2.9.5. Trust in information source

Mean ratings across all respondents were calculated for trust in the listed information sources, which included HI-EMA, nuclear agencies, the federal government, local authorities (e.g. the Mayor), emergency services and the national news media.

4.2.9.6. Demographic variables

Due to low numbers in some demographic categories, recoding was undertaken to consolidate groups. Employment was recoded into either employed or not employed. Education level was recoded as either less than degree level or degree level. Age was recoded as: 18-39, 40-59 or 60+. Having dependent children was recoded as: none; children <18 living with me; children >18 living with me; or children not living with me. Ethnicity was recoded as: Asian, Native Hawaiian, White, Mixed or Other.

4.2.9.7. Thematic analysis

All open text responses were analysed thematically (Braun and Clarke, 2006). This involved generating initial codes upon reading the data, extracting themes that arose and reporting these with reference to the pre-defined outcome variables. The following questions required open text responses: why did you not believe the warning to be genuine or from HI-EMA?; Why did you take no action/carry on with what you had been doing? And; what one or two things would you want to find out to help you prepare for a nuclear attack? Questions with 'other' response options also required open text elaboration. These were: how were you first made aware of the ballistic missile warning?; Which of the following best describes your immediate response to first hearing the warning?; Why did you take the action you did upon receiving the ballistic missile warning?; Please select any ways in which you attempted to find out information as to how to protect self/others following receipt of the warning; where did (your preparedness) information come from? And; why would you not wish to receive information regarding preparedness and protective actions prior to a nuclear attack?

4.3. Results

4.3.1. Demographics

There were 454 completed responses to the survey. Of these, 406 respondents were recruited from the market research panel (representing an 11% response rate) and 48 recruited from the University of Hawai'i. Table 4.1 shows demographic details for the sample. For comparison, data for the population of Hawai'i according to census data are also given (US Census Bureau, published June 21st, 2018). Males were under-represented in this sample, whilst over 50s were over-represented. The census data do not capture retirees or those unable to work. Despite this, the sample appeared to have an over-representation of those who were employed. Most respondents (n=300, 66%) reported having no dependent children; a total of 32% (n=147) had children who lived with them on January 13th, 2018.

Table 4.1. *Demographic profile of survey respondents*

Demographics (as of January 13th, 2018)		**Frequency**	**%**	**Population of Hawai'i %**	**% outside of population rate CI (95%)**
Gender	Male	200	44	50	3.5
	Female	253	56	50	3.5
	Prefer not to say	1	0.2		
	Total	454			
Age	Between 18-29 years old	73	16	16	0
	Between 30-39 years old	81	18	14	3.3
	Between 40-49 years old	65	14	12	1.4
	Between 50-59 years old	100	22	13	8.35
	Between 60-69 years old	104	23	12	10.4
	70 years or above	28	6	12	5.4
	Prefer not to say	3	0.7		
	Total	454			
Dependent Children	No	300	66	73	3.35
	I had a dependent child/children aged under 18 who was living with me	108	24	26.7	1.36
	I had a dependent child/children aged over 18 who was living with me	28	6	-	
	I had a dependent child/children aged under 18 but they did not live with me	7	1.5	-	
	I had children under and over 18 living with me	9	2	-	
	I had children both living and not living with me	2	0.4	-	
	Total	454			
Ethnicity	American Indian or Alaska Native	1	0.2	0.4	0.18
	Asian	210	46	37.6	6.52
	Black or African American	7	1.5	2.2	0.59
	Hispanic or Latino	5	1	10.7	9.16
	Native Hawaiian or Other Pacific Islander	61	13	10.1	2.39
	White	102	22	25.5	2.22
	Other	9	2	-	
	Mixed	54	12	24.2	10.99
	Prefer not to say	5	1	-	
	Total	454			
(Other ethnicities included Filipino; Portuguese, Spanish; Mexican)					
Employment Status	Employed, working 40 hours or more per week	231	51	47 (total employed)	1.65
	Employed, working 1-39 hours per week	88	19		
	Not employed, looking for work	19	4	2 (total unemployed of working age)	1.9
	Not employed, not looking for work	33	7		
	Retired	69	15	Not reported	

	Disabled, not able to work	14	3	Not reported
	Total	454		
Education	Less than high school degree	4	1	Not reported
	High school degree or equivalent (e.g. GED)	54	12	-
	Some college but not degree	102	22	-
	Associate degree	64	14	-
	Bachelor degree	130	29	-
	Graduate degree	98	22	-
	Prefer not to say	2	0.4	
	Total	454		

4.3.2. Preparedness

Table 4.2 shows the number of participants who had engaged in each preparedness activity. Of preparedness-related actions taken prior to January 13th, 2018, having obtained a flashlight and extra batteries was most frequently reported. Over or close to half had also put together a first aid kit, obtained a battery powered radio, stored a spare supply of medication or a 14-day supply of food and water.

Table 4.2. *Summary of preparedness actions taken prior to January 13th, 2018*

Action	**% within category: Nuclear attack preparedness (N)**	**% within category: Specific (non-nuclear) emergency preparedness (N)**	**% within category: General emergency preparedness (N)**	**% within category: Non-emergency reasons (N)**	**Total % (N)**
Obtained a flashlight (and extra batteries)	0.3 (1)	21.5 (80)	63 (233)	15.5 (58)	82 (372)
Put together a first aid kit	0 (0)	17 (56)	67 (221)	16 (53)	73 (330)
Obtained a battery powered radio	0 (0)	25 (71)	58 (162)	17 (47)	62 (280)
Stored a 14-day supply of food/water	0.4 (1)	29 (65)	52 (116)	18 (41)	49 (223)
Stored a spare supply of medication	0.4 (1)	18 (39)	56 (124)	26 (57)	49 (221)
Stored a bag with cash and important documents	0 (0)	16 (29)	56 (99)	27 (48)	39 (176)
Obtained walkie-talkies	0 (0)	16 (16)	42 (43)	42 (43)	22 (102)
Other	2 (2)	11.5 (11)	57 (54)	29 (28)	21 (95)

For participants who reported ‘other’ items, the most commonly stored related to *power, fuel* and *transport* including spare fuel for vehicles and generators. A small number of people stored batteries or chargers for devices and spare cell phones for communication. In addition to spare clothing, *hygiene* items included toiletries and toilet paper, wet weather gear and towels. The small number of individuals who had stored items for *pet care* primarily listed food and carriers. Items stored for *safety and security* were a mix of firearms and items for securing shelters such as plastic sheeting and window covers. One individual listed personal protective equipment. Despite a pre-set response option to this question being 14-days’ supply of food and water, some used the ‘other’ option to detail *food and drink*-related supplies. Whilst this did include methods for preparing food and drink such as gas stoves, can openers and a water purifier, this suggests that many individuals store food and water but not a 14-day supply.

Each preparedness action had been undertaken primarily for reasons of general preparedness (apart from obtaining walkie-talkies). Storing of a spare supply of medication (one respondent), storing 14-days’ supply of food and water (one respondent) and obtaining a flashlight (and extra batteries) (one respondent) were the only preparedness actions undertaken in case of nuclear attack.

A mean of 3.71 preparedness actions (absolute preparedness) were taken before January 13th, 2018. Participants had taken a mean of 3.03 actions specifically in preparation for an emergency (intentional), significantly more than the mean of 0.75 actions for incidental, non-emergency reasons ($t= 15.21$ ($df=453$), $p<0.0001$).

The scree plot for the principal component analysis (Figure 4.2) suggested loading of preparedness actions and perceived effort onto three factors. This was confirmed through analysis of the pattern matrix output (Table 4.3). Main loadings on component one were the preparedness actions rated as requiring the least effort. Component two was made up solely of the preparedness action behaviours. Component three comprised the five preparedness actions rated most highly for effort.

I chose to name the factors included in this analysis as preparedness *effort* (and *actions*) however alternative labels exist such as preparedness *usefulness*. It was intended that these labels signify a counterpoint to *efficacy* of actions. The accuracy of these labels for intended purpose could be ensured using a validation study which might involve checking the accuracy of labels with participants or having coders agree labels. However, for the purpose of this study, labelling was discussed with the supervisory team and agreed to be a robust way to identify levels of *perceived effort* following analysis.

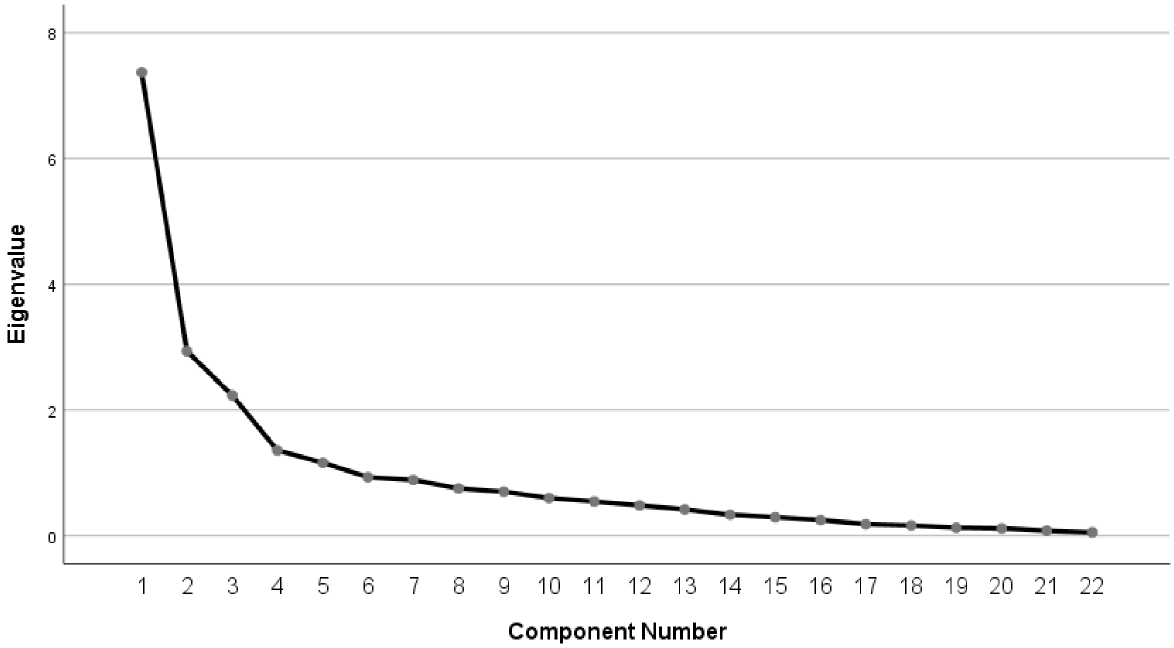


Figure 4.2. Scree plot output of principal components analysis of perceived effort of undertaking preparedness actions and rates at which preparedness actions were taken

Table 4.3. *Pattern matrix output of principal components analysis of perceived effort of undertaking preparedness actions and rates at which preparedness/actions were taken*

	Component		
	1	2	3
Preparedness Effort: obtain flashlight	0.99		-0.28
Preparedness Effort: compile a first aid kit	0.95		-0.10
Preparedness Effort: obtain battery powered radio	0.92		-0.11
Preparedness Effort: store medication	0.85		
Preparedness Effort: store cash/documents	0.84		
Preparedness Effort: shelter for 72 hours	0.72		0.14
Preparedness Effort: store (14 days) food/water	0.72	-0.13	0.19
Preparedness Effort: shelter for 1 week	0.64		0.33
Preparedness Effort: watch an online video	0.49		0.33
Preparedness Action: other		0.71	
Preparedness Action: store (14 days) food/water		0.69	
Preparedness Action: store medication		0.68	0.14
Preparedness Action: obtain battery powered radio		0.64	
Preparedness Action: store cash/documents		0.64	-0.15
Preparedness Action: compile a first aid kit		0.58	
Preparedness Action: obtain flashlight		0.54	
Preparedness Action: obtain walkie-talkies		0.45	
Preparedness Effort: evacuate to out of town			0.83
Preparedness Effort: attend a town hall meeting	-0.11		0.76
Preparedness Effort: evacuate within town	0.23		0.73
Preparedness Effort: obtain walkie-talkies		-0.19	0.60
Preparedness Effort: shelter for 2 weeks	0.41		0.51

A paired samples t-test comparing mean effort ratings was conducted, which confirmed significantly lower effort ratings for the first factor (mean=4.29) compared to the second group of ratings (mean=5.93) ($t=-12.76$ ($df=453$), $p<.0001$). These components were tentatively labelled as low preparedness effort ratings and high preparedness effort ratings.

Prior to January 13th, 2018, 44% (n=201) of respondents reported having received some information regarding general emergency preparedness and 20% (n=92) specifically for nuclear attack. More than half received no information for nuclear preparedness. The most frequently reported source of preparedness information was local news media (n=81, 36.5%) with ‘other’ sources (including work-place and educational institutions) accounting for the next most common response (n=29, 13%). Of those who reported receiving nuclear-specific preparedness information, 60% (n=134) had received it during the past year (at the time of survey). Only two respondents reported having received nuclear preparedness information from HI-EMA. Primary sources of nuclear preparedness information were on the job training or information provided via an employer and training or information within educational settings, such as cold war preparedness drills or more recently civil defence seminars at university. Two participants reported having received information directly from the University of Hawai’i. Additional sources of preparedness information included church and YouTube. Nuclear preparedness information received was felt to be sufficient by 32% (n=71) of respondents.

Tables 4.4 and 4.5 show associations between personal and predictor variables and intentional preparedness prior to January 13th, 2018.

Table 4.4. *Association between personal variables and intentional preparedness*

Variable and variable levels	% (N) of participants	% within variable level (N) scoring high for intentional preparedness	Intentional preparedness adjusted odds ratio (95% CI)
Gender			
Male	44 (200)	64.5 (129)	*Reference*
Female	56 (253)	50 (126)	**0.52 (0.35-0.78)***
Prefer not to say	0.2 (1)	100 (1)	*Not calculated*
Age			
18-39	34 (154)	46 (71)	*Reference*
40-59	36 (165)	58 (96)	**1.76 (1.09-2.82)***
60+	29 (132)	66 (87)	**2.29 (1.31-4.01)***
Prefer not to say	0.7 (3)	67 (2)	1.27 (0.11-14.86)
Dependent Children			
None	66 (300)	59 (176)	*Reference*
Children <18 living with me	26 (119)	50 (60)	0.89 (0.55-1.44)
Children >18 living with me	6 (28)	61 (17)	1.01 (0.44-2.32)
Children not living with me	1.5 (7)	43 (3)	0.41 (0.08-2.08)
Ethnicity			
Asian	46 (210)	58 (121)	*Reference*
Native Hawaiian	13 (61)	46 (28)	0.72 (0.39-1.33)
White	22 (102)	63 (64)	1.06 (0.63-1.76)
Other	6 (27)	59 (16)	1.07 (0.46-2.50)
Mixed	12 (54)	50 (27)	0.82 (0.44-1.53)
Employment			
Not Employed	30 (135)	61 (82)	*Reference*
Employed	70 (319)	54.5 (174)	1 (0.63-1.58)
Education level			
Less than degree level	36 (162)	59 (96)	*Reference*
Degree level	64 (292)	55 (160)	**0.64 (0.41-0.98)***

*= Significant result

Table 4.5. *Association between predictor variables and intentional preparedness*

Variable and variable levels	% (N) of participants	% within variable level (N) scoring high for intentional preparedness	Intentional preparedness adjusted odds ratio (95% CI)
General preparedness information			
A great deal	20 (93)	68 (63)	*Reference*
Some information	44 (201)	60 (121)	0.75 (0.43-1.30)
A little information	20 (92)	50 (46)	**0.48 (0.25-0.91)***
No information	15 (68)	38 (26)	**0.28 (0.14-0.56)***
Nuclear preparedness information			
A great deal	5 (23)	61 (14)	*Reference*
Some information	20 (92)	64 (59)	1.23 (0.45-3.33)
A little information	23.5 (107)	65 (70)	1.37 (0.51-3.66)
No information	51 (232)	49 (113)	0.63 (0.25-1.61)
Source of preparedness information			
Local authorities	10 (23)	69.5 (16)	*Reference*
Social media	6 (14)	64 (9)	0.80 (0.17-3.84)
Local news media	36 (81)	63 (51)	0.70 (0.23-2.13)
National news media	5 (11)	64 (7)	0.77 (0.14-4.05)
Friends or family	9 (20)	75 (15)	1.03 (0.24-4.51)
National government sources	7 (16)	75 (12)	1.86 (0.39-8.94)
Nuclear agencies	0.4 (1)	0 (0)	*Not calculated*
Emergency services	0.9 (2)	50 (1)	0.58 (0.02-13.29)
The military	4 (9)	67 (6)	1 (0.17-5.85)
Other	13 (29)	65.5 (19)	0.87 (0.24-3.19)
Cannot recall	7 (16)	44 (7)	0.28 (0.06-1.25)
How recently informed			
During the past year	60 (134)	62 (83)	*Reference*
1 – 5 years ago	30 (66)	67 (44)	1.45 (0.73-2.86)
6 – 15 years ago	4 (9)	67 (6)	1.59 (0.33-7.60)
More than 15 years ago	6 (13)	77 (10)	1.68 (0.39-7.27)
Information sufficiency			
Yes	32 (71)	75 (53)	*Reference*
No	43 (96)	66 (63)	0.66 (0.31-1.44)
Don't know	25 (55)	49 (27)	**0.23 (0.10-0.54)***
Belief in protection from military			
Fully protected	14 (64)	58 (37)	*Reference*
Partially protected	40 (180)	65 (117)	1.47 (0.80-2.73)
Not protected	19 (88)	53 (47)	0.81 (0.41-1.60)
Don't know	27 (122)	45 (55)	0.60 (0.31-1.15)
Low perceived preparedness effort (continuous variable)	4.3 (mean total)	4 (mean within variable)	0.94 (0.87-1.01)
High perceived preparedness effort (continuous variable)	5.9 (mean total)	5.8 (mean within variable)	0.98 (0.90-1.07)

*= Significant result

Adjusted for demographic variables: gender, age, dependent children, ethnicity, employment and education.

4.3.2.1. Pre-incident communication preferences

Table 4.6 shows the number of participants who reported a desire to receive pre-incident communications for nuclear preparedness. Most (83.5%) reported that they would wish to receive information regarding what actions they could take to prepare for a nuclear attack. Of this group, 90.5% wished to have this information preferably any time before an attack is known as opposed to only when an attack is known to be imminent. For those not wishing to receive pre-incident preparedness information the most frequently cited reason was 'I don't believe I could be protected if Hawai'i was attacked' (57%).

Table 4.6. *Summary of responses relating to desire for pre-incident communications*

	% (Frequency)
Would you want to receive information regarding what actions you could take to prepare for a nuclear attack?	
Yes	83 (379)
No	16.5 (75)
Total	(454)
When would be the best time for you to receive information regarding actions to take in a nuclear attack?	
Preferably any time before an attack is known	90.5 (343)
Only when an attack is known to be imminent	9.5 (36)
Total	(379)
Note: Respondents who selected 'No' in response to the question as to whether they would want to receive pre-incident communications were not shown this question	
Why would you not wish to receive preparedness information?	
I don't believe I could be protected if Hawai'i was attacked	57 (43)
I don't believe Hawai'i will be attacked with a nuclear device	11 (8)
I do not feel it would be possible to undertake actions advised	7 (5)
I would be too afraid	4 (3)
Other	21 (16)
Total	7(5)
Note: Respondents who selected 'Yes' in response to question as to whether they would want to receive pre-incident communications were not shown this question	

Fatalistic attitudes were also evident in open text responses as the primary additional reason for not wishing to receive preparedness communications for nuclear attack.

This was often related to aspects specific to Hawai'i such as the size of the islands and building materials. One respondent referred to the perceived lack of ability in working class communities to take recommended preparedness actions (stockpile; save money; evacuate). A small number reported that they would not wish to survive a nuclear attack based on expected quality of life. Two respondents suggested they "*know enough*".

Respondents were asked to detail two key pieces of information that they would like to know to help them prepare for a nuclear attack. Responses were grouped under the following headings: *sheltering; evacuation; preparedness actions; protections in the event; defence systems* and; *communication*.

Forms of *sheltering*-related questions or reported information needs were referred to 140 times. Many requested information as to the location of nuclear shelters on the islands. Many asked how they would know whether to stay at home or leave for a designated shelter. Others wished to improve the effectiveness of their home as a shelter (e.g. "*fortification"*), including ways to create a functional toilet, and for how long to shelter. Other notable shelter-related responses were for alternative protections to sheltering at home such as getting underground or using storm shelters, and what building materials are safest, including an explanation as to why sheltering is recommended. Recommendations, if unable to shelter, such as if driving or outside, were also requested.

Whilst few explicitly used the term *evacuation*, 53 respondents asked variations on where they should go if an attack was imminent. Questions related to the best modes of transport (such as if roads are blocked) and where, if anywhere, would "*safe areas*" be.

Desire for information about *preparedness* largely related to knowing what to include in an emergency kit or amounts of supplies to store. Again, some from this group said they would require preparedness knowledge in case they lacked an appropriate shelter.

Other respondents expressed concern around "*national defence capability and local government response preparation*" above personal preparedness. This included the ability of the military to intercept a nuclear missile and "*what level/length of protection that Hawai'i is prepared for*". One respondent suggested that knowing that intercept capability is 100% accurate is the only way to not be afraid.

Information to be used in the event of a nuclear blast, as opposed to preparedness, was desired by some. Much of this was general information including how food and drink would be supplied to affected groups, how communication with loved ones might be achieved and, commonly, how to protect not just oneself, but one's family. Others expressed a desire for nuclear specific information: the range of potential damage (would other islands be affected by a blast in Honolulu?); how to recognise radiation poisoning; how to avoid exposure; how long radiation would take to clear (including how long to remain in a shelter) and; the longer-term effects of fallout.

The final category of responses related more closely to *emergency risk communication*, i.e. information that individuals would like to receive in warning messages sent when an attack is imminent. Most commonly, this included who launched the attack, where exactly it will hit, and how long until impact.

4.3.3. Adherence with protective instructions

Table 4.7 shows the proportion of respondents who engaged in various activities after receiving the emergency alert. Respondents most frequently reported making efforts to verify that the information was correct or genuine and attempting to make contact with friends or family using social media or by phone. Only 8% reported that they sought immediate shelter. 65 participants were not shown this question as they received the retraction message simultaneously.

Table 4.7. *Summary of immediate responses to the alert*

	% (Frequency)
Which of the following best describes your immediate response to first hearing the warning?	
Made efforts to verify that the information was correct/the warning was genuine	47 (186)
Got in contact with/tried to get in contact with friends/family using social media or by phone	32 (144)
Took no action/carried on with what I was doing	22 (87)
Made efforts to find out protective actions I could take	16 (63)
Sought immediate shelter	9 (36)
Immediately initiated a pre-arranged plan	4.5 (18)
Left home/the place I was at to seek out friends or family	2 (8)
Other	10 (38)
Note: respondents who selected 'I did not hear it until it was known to be a false alarm' in response to the previous question did not see this question	
Why did you take the action you did upon receiving the ballistic missile warning?	
I wished to verify that the information received was accurate	42 (189)
I wanted to protect my family	24 (111)
I felt unprepared/lacked knowledge as to what actions I should take	19 (86)
I wanted to be with family/friends	16 (74)
I felt prepared/knowledgeable as to what actions I should take	8 (36)
I thought my actions would protect me	6 (28)
I did what the warning advised me to do (regardless of whether I felt it the safest action or not)	5 (21)
I wanted to help others (strangers) who may have been hurt	2 (10)
My family/friends and I had a pre-arranged meeting place for such an emergency	1 (6)
Other	6 (28)
Please select any ways in which you attempted to find out information as to how to protect self / others following receipt of the warning	
Contact friends/family	39 (176)
Searched online (web search)	32 (145)
Checked on social media	31 (141)
N/A - (I did not seek information about protective actions when I received the warning)	16 (73)
Contacted another agency/authority	5 (24)
Contacted HI-EMA	3 (13)
Other	22 (101)

Three-hundred and thirty participants (85%) were found to be adherent based on the definition of incidental adherence. Fifty-nine (15%) were found to be non-adherent. Non-adherent individuals included those who left home to seek family and friends (n=8), two who detailed 'other' non-adherent actions upon receiving the warning whilst at home, and those who were outdoors but did not seek shelter (n=47). According to the definition for deliberate adherence 51 (13%) were found to have been adherent and 338 (87%) non-adherent. In this case, adherent individuals were those who sheltered (n=44), initiated a pre-arranged plan (n=2) or did both (n=5).

Tables 4.8 and 4.9 show associations between adherence and predictors. Respondents were less likely to have been incidentally adherent if they had children over 18 living at home, were native Hawaiian or were educated to degree level. Having been outdoors upon receiving the alert was significantly associated with incidental adherence, but not with deliberate adherence. Being of mixed or other ethnicity was significantly associated with deliberate adherence. Those believing an attack to be imminent were more likely to be deliberately adherent.

Thirty-eight participants responded ‘other’ to describe their immediate response to the warning. Of these, most sought further information. This included one respondent who reported that they waited for the sounding of the siren system for authentication. Other respondents could be described as incidentally adherent to the message to shelter.

Only one respondent reported taking a specific protective action: closing their windows.

A small number reported actions intended to be protective, but are actually considered non-adherent, such as going to the local store for supplies or terminating their dialysis treatment to return home. One respondent reported actions that could be classed as actively non-adherent.

Of those respondents who sought further information, checking television news was the most common method. Twenty-seven turned on the radio. Emergency services and the military were authorities most commonly contacted for information. This included calling 911 (one respondent found the line was busy) or police departments directly. Others contacted friends or family serving in military positions. A small number reported contacting civil defence or public health agencies (county civil defence, department of public safety, Computer Emergency Response Team).

Taking no action or carrying on with what they were doing was reported by 19% (n=87). Those who selected this response offered four key reasons as to why they took no action. These were categorised as: *fatalism, denial, unawareness* and *uncertainty*.

Fatalism included statements expressing an inability to avoid what is believed to be inevitable such as “*whatever was to happen would happen”; “if it's coming, we're gonna die anyway”* and a wish to find a positive in what was believed to be final moments.

Denial was not as common a category of response as others but included statements such as *“unlikely to be accurate enough to hit its target”.*

Unawareness included unawareness of actions that could be taken: "*we didn't know what to do. It was the first time ever getting that alert, ever*", lack of awareness of the potential efficacy of taking protective actions and unawareness of the warning having occurred: *"I seldom look at my phone".*

Many respondents illustrated *uncertainty* when they reported not acting due to not feeling that they had adequate information to do so effectively. For example, *"I didn't know if my location was ground zero so no sense driving somewhere else".*

Table 4.8. *Association between personal variables and individual responses to missile alert*

Variable and variable levels	% (N) of participants	% within variable level (N) incidentally adhering to instruction	Incidental adherence adjusted odds ratio (95% CI)	% within variable level (N) deliberately adhering to instruction	Deliberate adherence adjusted odds ratio (95% CI)
Gender					
Male	44 (172)	87 (150)	*Reference*	13 (22)	*Reference*
Female	55.5 (216)	83 (179)	0.69 (0.38-1.29)	13 (29)	0.98 (0.51-1.86)
Prefer not to say	0.3 (1)	100 (1)	*Not Calculated*	0 (0)	*Not Calculated*
Age					
18-39	35 (138)	88 (122)	*Reference*	16 (22)	*Reference*
40-59	37 (144)	82 (118)	0.71 (0.34-1.46)	16 (23)	0.93 (0.47-1.86)
60+	27 (104)	85 (88)	0.87 (0.36-2.10)	6 (6)	0.39 (0.13-1.14)
Prefer not to say	0.8 (3)	67 (2)	0.12 (0.01-1.64)	0 (0)	*Not Calculated*
Dependent Children					
None	62 (242)	88 (212)	*Reference*	11 (26)	*Reference*
Children <18 living with me	29.5 (115)	83 (96)	0.85 (0.42-1.71)	21 (24)	1.65 (0.85-3.21)
Children >18 living with me	7 (26)	69 (18)	**0.39 (0.13-0.89)***	0 (0)	*Not Calculated*
Children not living with me	1.5 (6)	67 (4)	0.25 (0.04-1.70)	17 (1)	2.77 (0.29-26.85)
Ethnicity					
Asian	45.5 (177)	86 (152)	*Reference*	8 (15)	*Reference*
Native Hawaiian	14 (55)	73 (40)	**0.39 (0.18-0.86)***	13 (7)	1.28 (0.47-3.51)
White	22 (85)	88 (75)	1.13 (0.50-2.56)	13 (11)	1.89 (0.80-4.45)
Other	6 (24)	79 (19)	0.63 (0.20-1.93)	25 (6)	**4.29 (1.35-13.29)***
Mixed	12 (48)	92 (44)	1.64 (0.52-5.14)	25 (15)	**3.16 (1.31-7.61)***
Employment					
Not Employed	28 (108)	85 (92)	*Reference*	10 (11)	*Reference*
Employed	72 (281)	85 (238)	1.20 (0.59-2.45)	14 (40)	1.09 (0.49-2.44)
Education level					
Less than degree level	36.5 (142)	91 (129)	*Reference*	11 (16)	*Reference*
Degree level	63.5 (247)	81 (201)	**0.36 (0.17-0.74)***	14 (35)	1.42 (0.71-2.86)

*= Significant result

Table 4.9. *Association between predictor variables and individual responses to missile alert*

Variable and variable levels	% (N) of participants	% within variable level (N) incidentally adhering to instruction	Incidental adherence adjusted odds ratio (95% CI)	% within variable level (N) deliberately adhering to instruction	Deliberate adherence adjusted odds ratio (95% CI)
Location upon receiving warning					
Indoors	84 (328)	97 (317)	*Reference*	12 (39)	*Reference*
Outdoors	16 (61)	21 (13)	**0.00 (0.00-0.01)***	20 (12)	1.75 (0.79-3.87)
By what means was the message received?					
SMS from HI-EMA	74 (289)	86 (248)	*Reference*	13 (38)	*Reference*
Warning siren	2 (8)	75 (6)	0.94 (0.14-6.50)	25 (2)	4.10 (0.60-27.90)
National news	0.5 (2)	100 (2)	*Not Calculated*	0 (0)	*Not Calculated*
Local news	2.5 (10)	100 (10)	*Not Calculated*	20 (2)	1.91 (0.30-12.22)
Word of mouth	18 (69)	80 (55)	0.58 (0.28-1.21)	11.5 (8)	0.79 (0.33-1.87)
Other means	3 (11)	82 (9)	1.07 (0.21-5.52)	9 (1)	1.03 (0.12-9)
Was the message believed to be from HI-EMA?					
Yes	79 (308)	83 (257)	*Reference*	15 (45)	*Reference*
No – a different source	5 (18)	89 (16)	1.46 (0.31-6.93)	5.5 (1)	0.36 (0.05-2.91)
No- hoax	16 (63)	90 (57)	1.96 (0.77-5.02)	8 (5)	0.49 (0.17-1.39)
Was an attack believed to be imminent?					
No (hoax or mistake)	46.5 (181)	87 (157)	*Reference*	5 (9)	*Reference*
Yes	53 (208)	83 (173)	0.83 (0.45-1.54)	20 (42)	**5.14 (2.31-11.42)***
Prior level of disaster preparedness information received					
A great deal	19 (75)	83 (62)	*Reference*	8 (6)	*Reference*
Some information	44 (172)	87 (149)	1.18 (0.53-2.63)	16 (28)	2.60 (0.96-7)
A little information	21.5 (84)	81 (68)	0.74 (0.30-1.80)	12 (10)	2.23 (0.70-7.04)
No information	15 (58)	88 (51)	1.11 (0.38-3.24)	12 (7)	1.97 (0.57-6.82)
Prior level of nuclear preparedness information received					
A great deal	6 (22)	86 (19)	*Reference*	23 (5)	*Reference*
Some information	20 (79)	91 (72)	1.71 (0.37-7.96)	19 (15)	1.03 (0.30-3.52)
A little information	23 (91)	77 (70)	0.44 (0.11-1.80)	14 (13)	0.69 (0.20-2.36)
No information	51 (197)	86 (169)	0.76 (0.19-3.02)	9 (18)	0.35 (0.11-1.13)
Belief in protection from military					
Fully protected	15 (57)	88 (50)	*Reference*	19 (11)	*Reference*
Partially protected	38 (148)	84 (125)	0.84 (0.32-2.16)	10 (15)	0.50 (0.21-1.23)
Not protected	20 (77)	88 (68)	1.31 (0.42-4.04)	19 (15)	1.11 (0.44-2.79)
Don’t know	27.5 (107)	81 (87)	0.63 (0.24-1.68)	9 (10)	0.47 (0.18-1.27)

Intentional preparedness	56 (256)	71 (182)	0.66 (0.36-1.23)	11 (28)	1.07 (0.57-2.01)
Perceived level of effort involved in sheltering for 72hrs	4.7 (mean total)	4.6 (mean within variable)	0.97 (0.89-1.06)	5 (mean within variable)	1.03 (0.90-1.13)

*= Significant result

Adjusted for demographic variables: gender, age, dependent children, ethnicity, employment and education.

Respondents were motivated to take the actions that they did by a desire to verify that the information received was accurate, to protect their family or to be with family or friends. Among reasons given for taking actions in response to the alert, more respondents reported feeling unprepared or lacking knowledge as to what actions they should take, than feeling prepared or knowledgeable. This is reflected in respondents attempting to find out information by contacting friends and family, whilst 32% searched online and 31% checked on social media. Only 5% reported that they did what the warning advised them to do.

In analysis of 'other' reasons given for actions taken in response to the warning, the following themes emerged: *Being prepared (and wishing to adhere); Lacking preparedness* and; *Fatalism*.

Those who acted on preparedness knowledge cited hurricane and tsunami protection, though mentioned no specific actions. One respondent did recall nuclear specific disaster preparedness.

Others referred to a need to find shelter, be it their own home, shelter in low altitude locations or finding what they perceived to be a more effective shelter.

Whilst knowledge of protective actions (*shelter-in-place*) were referred to by one further respondent, some who reported a lack of preparedness stated not knowing how to respond or being confused.

Further reasons for not taking protective steps were a belief that the islands would be destroyed by nuclear attack (a belief shared by many) or at least communications being wiped out. These attitudes resulted in a many making statements such as there was "*nothing could be done but wait*".

4.3.4. Belief in message

Table 4.10 shows whether participants believed the message had been sent by HI-EMA and if an attack was imminent. 69% of those who received the alert (before being made aware it was a false alarm) believed it to have been a genuine HI-EMA warning. Of that group, 53% also believed an attack to be imminent. Among the group who believed an attack to be imminent 13% adhered to protective instructions.

Table 4.10. *Summary of responses related to whether respondents believed the alert*

	% (Frequency)
Did you believe that it had been sent by HI-EMA?	
Yes	69 (312)
No – I believed the warning to be a hoax	14 (63)
No – I believed the warning to be from a source other than HI-EMA	4 (18)
N/A (I did not hear it until it was known to be a false alarm)	13 (61)
Total	(454)
Did you believe that an attack was imminent?	
Yes	53 (208)
No - I believed the warning to be a hoax or a mistake or that it would come to nothing	47 (182)
Total	(390)

Note: those who selected 'I did not hear it until it was known to be a false alarm' did not see this question

Tables 4.11 and 4.12 show associations between personal and predictor variables with believing an attack to be imminent upon receiving the warning and subsequently adhering to protective instructions. People were significantly more likely to believe an attack to be imminent if they were: female, had children under 18 living with them, had received no previous general disaster preparedness information, did not believe preparedness information to have been sufficient and perceived there to be moderate to very high risk of nuclear attack occurring against Hawai'i. Individuals aged over 40 years, those who did not believe the warning to be a genuine HI-EMA alert and those who received disaster preparedness information between six and 15 years previously were significantly less likely to believe an attack to be imminent. Individuals of mixed ethnicity and those first alerted to the warning via emergency siren were significantly more likely to believe an attack imminent as well as adhere to protective instructions, whilst individuals who believe Hawai'i to be partially protected by the military were less likely to believe an attack was imminent or to adhere with the instruction to shelter than those who believe Hawai'i to be fully protected by the military.

Table 4.11. *Associations between personal variables and believing an attack to be imminent coupled with adhering to protective instructions/taking protective action*

Variable and variable levels	% (N) of participants	% within variable level (N) of participants believing an attack to be imminent	adjusted odds ratio (95% CI)	% within variable level (N) of participants believing an attack to be imminent AND adhering to protective instructions	adjusted odds ratio (95% CI)
Gender					
Male	44 (172)	44 (76)	*Reference*	9 (16)	*Reference*
Female	55.5 (216)	61 (131)	**1.87 (1.21-2.88)***	12 (26)	1.10 (0.51-2.38)
Prefer not to say	0.3 (1)	100 (1)	*Not calculated*	0 (0)	*Not calculated*
Age					
18-39	35 (138)	64 (89)	*Reference*	14 (19)	*Reference*
40-59	37 (144)	51 (73)	**0.53 (0.31-0.89)***	12.5 (18)	1.21 (0.53-2.75)
60+	27 (104)	43 (45)	**0.52 (0.28-0.95)***	5 (5)	0.44 (0.12-1.56)
Prefer not to say	0.8 (3)	33 (1)	0.40 (0.03-5.03)	0 (0)	*Not calculated*
Dependent Children					
None	62 (242)	46.5 (113)	*Reference*	9 (22)	*Reference*
Children <18 living with me	29.5 (115)	67 (77)	**2.15 (1.27-3.63)***	16.5 (19)	1.06 (0.49-2.31)
Children >18 living with me	7 (26)	58 (15)	1.84 (0.79-4.29)	0 (0)	*Not calculated*
Children not living with me	1.5 (6)	50 (3)	1.08 (0.19-6.10)	17 (1)	3.36 (0.27-41.65)
Ethnicity					
Asian	45.5 (177)	48 (86)	*Reference*	7 (13)	*Reference*
Native Hawaiian	14 (55)	76 (42)	2.56 (1.24-5.27)	9 (5)	0.71 (0.22-2.31)
White	22 (85)	48 (41)	1.19 (0.68-2.06)	12 (10)	2.25 (0.82-6.14)
Other	6 (24)	50 (12)	0.90 (0.36-2.24)	12.5 (3)	2.43 (0.51-11.65)
Mixed	12 (48)	56 (27)	1.04 (0.53-2.07)	23 (11)	**3.32 (1.21-9.14)***
Employment					
Not Employed	28 (108)	49.5 (54)	*Reference*	8 (9)	*Reference*
Employed	72 (281)	55 (154)	1.03 (0.62-1.71)	12 (33)	1.06 (0.40-2.84)
Education level					
Less than degree level	36.5 (142)	57 (82)	*Reference*	10 (14)	*Reference*
Degree level	63.5 (247)	51 (126)	0.88 (0.56-1.40)	11 (28)	1.44 (0.65-3.20)

*= Significant result

Table 4.12. *Associations between variables and believing an attack to be imminent coupled with adhering to protective instructions/taking protective action*

Variable and variable levels	% (N) of participants	% within variable level (N) of participants believing an attack to be imminent	adjusted odds ratio (95% CI)	% within variable level (N) of participants believing an attack to be imminent AND adhering to protective instructions	adjusted odds ratio (95% CI)
Location upon receiving warning					
Indoors	84 (328)	53 (174)	*Reference*	10 (33)	*Reference*
Outdoors	16 (61)	56 (34)	1.05 (0.57-1.92)	15 (9)	2.13 (0.81-5.65)
By what means was the message received?					
SMS from HI-EMA	74 (289)	57 (164)	*Reference*	11 (31)	*Reference*
Warning siren	2 (8)	62.5 (5)	0.83 (0.16-4.17)	25 (2)	**18.30 (1.04-322.25)***
National news	0.5 (2)	0 (0)	*Not calculated*	0 (0)	*Not calculated*
Local news	2.5 (10)	60 (6)	1.25 (0.31-5.05)	20 (2)	5.35 (0.54-52.94)
Word of mouth	18 (69)	40.5 (28)	0.52 (0.29-0.92)	10 (7)	1.24 (0.43-3.59)
Other means	3 (11)	45 (5)	0.70 (0.19-2.60)	0 (0)	*Not calculated*
Was the message believed to be from HI-EMA?					
Yes	79 (309)	65 (201)	*Reference*	13 (41)	*Reference*
No – a different source	5 (18)	33 (6)	**0.23 (0.07-0.72)***	0 (0)	*Not calculated*
No- hoax	8 (63)	1.5 (1)	**0.01 (0.00-0.05)***	1.5 (1)	*Not calculated*
Prior level of disaster preparedness information received					
A great deal	19 (75)	43 (32)	*Reference*	7 (5)	*Reference*
Some information	44 (173)	52 (90)	1.46 (0.81-2.63)	13 (23)	1.93 (0.60-6.25)
A little information	21.5 (84)	56 (47)	1.72 (0.86-3.42)	9.5 (8)	1.34 (0.34-5.24)
No information	15 (58)	67 (39)	**2.68 (1.22-5.86)***	10 (6)	1.13 (0.27-4.76)
Prior level of nuclear preparedness information received					
A great deal	6 (22)	45 (10)	*Reference*	14 (3)	*Reference*
Some information	20 (79)	59 (47)	1.85 (0.63-5.38)	16 (13)	0.92 (0.17-5.01)
A little information	23 (91)	53 (48)	1.32 (0.46-3.77)	10 (9)	0.51 (0.94-2.78)
No information	51 (198)	52 (103)	1.22 (0.45-3.32)	8 (17)	0.38 (0.07-1.93)
Source of preparedness information					
Local authorities	12 (23)	48 (11)	*Reference*	9 (2)	*Reference*
Social media	7 (14)	78.5 (11)	1.71 (0.32-9)	21 (3)	5.58 (0.37-85.07)
Local news media	35 (67)	57 (38)	0.79 (0.26-2.4)	10 (7)	3.88 (0.44-33.89)

National news media	5 (9)	55.5 (5)	0.56 (0.09-3.47)	0 (0)	*Not calculated*
Friends or family	9 (18)	50 (9)	1.01 (0.25-4.07)	11 (2)	16.64 (0.82-337.28)
National government sources1	7 (13)	61.5 (8)	1.38 (0.30-6.30)	15 (2)	2.90 (0.19-43.83)
Nuclear agencies	0.5 (1)	100 (1)	*Not calculated*	0 (0)	*Not calculated*
Emergency services	1 (2)	100 (2)	*Not calculated*	0 (0)	*Not calculated*
The military	4 (7)	43 (3)	1.16 (0.16-8.40)	14 (1)	1.77 (0.05-58.26)
Other	12 (23)	52 (12)	0.65 (0.17-2.48)	26 (6)	16.49 (1.49-181.97)
Cannot recall	8 (15)	33 (5)	0.22 (0.04-1.15)	13 (2)	39.98 (0.85-1869.75)
How recently informed of preparedness information					
During the past year	60 (116)	59 (68)	*Reference*	14 (16)	*Reference*
1 – 5 years ago	31 (59)	58 (34)	0.97 (0.47-1.98)	10 (6)	0.88 (0.25-3.08)
6 – 15 years ago	3 (6)	17 (1)	**0.10 (0.01-1)***	17 (1)	*Not calculated*
More than 15 years ago	6 (11)	18 (2)	0.20 (0.03-1.15)	18 (2)	*Not calculated*
Belief that preparedness information was sufficient					
Yes	31 (59)	41 (24)	*Reference*	10 (6)	*Reference*
No	46 (88)	67 (59)	**4.06 (1.78-9.22)***	18 (16)	1.75 (0.44-6.93)
Don't know	23 (45)	49 (22)	1.84 (0.75-4.52)	7 (3)	0.54 (0.09-3.09)
Belief in protection from military					
Fully protected	15 (57)	53 (30)	*Reference*	17.5 (10)	*Reference*
Partially protected	38 (149)	52 (77)	0.87 (0.45-1.67)	7 (11)	**0.34 (0.12-1.01)***
Not protected	20 (77)	58 (45)	1.29 (0.62-2.70)	14 (11)	0.64 (0.21-1.92)
Don't know	27 (107)	52 (56)	0.84 (0.42-1.69)	9 (10)	0.49 (0.16-1.50)
Perceived likelihood of nuclear attack					
No risk at all	9 (35)	31 (11)	*Reference*	11 (4)	*Reference*
A little risk	49 (190)	37 (70)	1.22 (0.55-2.74)	7 (13)	0.33 (0.07-1.45)
Moderate risk	30 (118)	74.5 (88)	**5.52 (2.33-13.08)***	12 (14)	0.24 (0.05-1.07)
Quite a high risk	7 (27)	81 (22)	**6.29 (1.78-22.19)***	30 (8)	0.77 (0.13-4.52)
Very high risk	5 (20)	85 (17)	**11.35 (2.59-49.77)***	15 (3)	0.29 (0.04-1.87)
Intentional Preparedness	48 (217)	50 (109)	0.95 (0.61-1.46)	13 (28)	0.99 (0.47-2.09)

*= Significant result

Note: Adjusted for demographic variables: gender, age, dependent children, ethnicity, employment and education.

4.3.4.1. Trust in source

Table 4.13 shows the ranking of trust that participants gave to sources of information. HI-EMA was the most trusted source to provide nuclear emergency preparedness information, followed by nuclear agencies and the federal government. Medical staff and online forums/social media were rated lowest.

Table 4.13. *Rankings of trust in pre-incident nuclear preparedness information sources*

Rank (1 = most highly trusted; 12 = least trusted)	**Source**	**Mean trust ranking**	**Standard Deviation**
1	HI-EMA	3.85	2.89
2	Nuclear agencies (e.g. the International Atomic Energy Agency (IAEA); Centres for Disease Control and Prevention (CDC))	4	2.87
3	Federal Government	5.10	2.91
4	Local authorities (e.g. the Mayor)	5.50	3.01
5	Emergency services (e.g. police; fire brigade)	6.08	2.72
6	National News Media	6.83	2.95
7	Local News Media	6.95	3.48
8	The Military	7.02	3.62
9	Friends and Family	7.03	3.69
10	Scientists	7.67	3.20
11	Medical staff or resources	8.26	2.65
12	Online Forums/social media	9.36	2.75

Note: Rank 1 = most likely to trust if communicating information; 12 = least likely

4.4. Discussion

For many who experienced the false nuclear alert in Hawai'i, it represented a genuine moment of fear. In this study, 53% (n=208) of respondents reported that at the time, they believed a nuclear attack was imminent and while they undertook sheltering in line with the message instruction, those who doubted that message were ultimately right to do so. Further, participants had undertaken approximately three actions for emergency preparedness and a large majority reported a desire to receive greater preparedness education. The incident therefore represents an unprecedented chance to study how a population reacted to a credible nuclear alert and how we can better prepare our populations for such an eventuality.

4.4.1. Preparedness

An aim of this study was to identify how many people possess adequate supplies within their home to allow them to cope with an emergency and the amount who possess these items specifically to prepare for a nuclear emergency.

The Hawai'i population appear reasonably well prepared for a general emergency, with 81%, for example, reporting that they have put together a first aid kit. Indeed, when asked about a range of preparedness behaviours, it was apparent that significantly more preparedness actions were taken intentionally for emergency purposes than had been taken incidentally – in other words the presence of flashlights or first aid kit in the house was typically a deliberate attempt to prepare for an emergency rather than reflecting day to day acquisition of useful tools. Interestingly, subjective accounts in other sources seem to disagree with this finding. For example, Wallis (2018) in a perspective piece for the Washington Post stated:

> *"We're not really disaster preppers on Oahu. Most of us grab our hurricane provisions in a mad rush…in the days before a storm hits. Our sense of community, known as ohana, is strong. We all sink or swim together. So that was the excuse I'd given myself for not ensuring that we were prepared as a family to shelter"*

Whilst this exact sentiment was not expressed in response to this survey, it is perhaps echoed in fatalistic reasons given by some for not preparing for an emergency, and to explain their preference to not receive preparedness information. For example:

> *"I feel it's not worth trying to over plan and try(ing) to prepare for every situation. Some things will happen and so be it"*

In this study, however, such attitudes appeared to be in the minority. In comparison with levels of preparedness identified elsewhere (previous studies such as Page et al., 2008 and my focus group study, Chapter 3) this survey data suggest that preparedness in the Hawai'i public is remarkably high.

For some of the preparedness actions, the apparently high level of uptake may appear unlikely. For example, 44% of respondents reported having obtained and stored a 14-day supply of water. In practice, this may be less effortful than it appears. Figure 4.3 shows what the City and County of Honolulu's Department of Emergency Management believe a 14-day supply of water per person looks like.

Figure 4.3. A 14-day minimum drinking water supply for emergency survival (7 Gallons of water per person. Ex: 1 x 10g Water Cooler or 2 x 5g or 7 x 1g jugs (City and County of Honolulu's Department of Emergency Management, 2019). Permission for use requested from https://dod.hawaii.gov/hiema/

For other preparedness activities, this data suggests there might be room for improvement. Obtaining walkie-talkies was rated as being amongst the most effortful preparedness actions (together with being prepared to shelter or evacuate for prolonged periods). This could explain why it was the least frequently undertaken preparedness action. It is unclear what people find effortful about buying walkie-talkies, but we could speculate that it is perceived unavailability or cost relative to other items, or perhaps more likely, that they are deemed an unnecessary item since mobile and smart phones became a universally owned and more functional commodity.

Regarding individual predictors of preparedness, relatively few variables that were tested showed any significant association with a participant having intentionally prepared for an emergency. In addition to those over 40 years old being more likely to have intentionally prepared than younger respondents, females, those educated to degree level, those who reported having received little or no general disaster preparedness information and those who expressed not knowing whether the preparedness information they had received was sufficient, were all less likely to have taken preparedness measures.

That people who feel they have received sufficient information tended to be more prepared is supported by many previous studies (e.g. Maidl and Buchecker, 2015; Mileti and Fitzpatrick, 1992; Perko et al., 2014). The finding lends additional weight to the idea that educating the public about disaster risks may have public health benefits. A problem exists, however, in terms of causality. It remains unclear whether some people are simply inclined to both prepare and to seek information, or if it is receipt of information that causes a person to prepare. Indeed, it is possible that both are true.

In this survey, no associations between preparedness and perceived likelihood of a nuclear attack, or disaster of unspecified type occurring during respondent's lifetimes were found to be significant. This is in contrast to previous research, reviewed in Chapter 2, that suggests that preparedness behaviour is associated with perceived likelihood, coping efficacy, perceived front-line preparedness and worry, while information seeking specific to nuclear emergencies is influenced by cognitive factors including, but not limited to, perceived likelihood and likely personal impact of a nuclear disaster, perceived coping efficacy and worry (Lee and Lemyre, 2009).

Where nuclear-specific preparedness was found to be lacking, this could be attributed to a lack of preparedness knowledge. Approximately half of respondents reported not having received pre-nuclear incident preparedness information prior to January 13th, 2018. Furthermore, threats that are perhaps more salient, such as proximity to an active volcano, are also viewed as more enduring risks and considered a higher priority for preparedness. Taking actions to prepare for risks perceived as more likely to occur negates the need to separately prepare for newer risks such as nuclear attack. An interesting point of comparison would be another population who are historically at less risk of catastrophic disaster (i.e. have not been recently suggested to be within the reach of nuclear weapons belonging to a hostile state, and do not reside in proximity to an active volcano).

Moreover, whilst the population appear well-prepared, the low rates of incidental preparedness suggest that preparedness planners cannot rely on the public already possessing recommended items, but instead should use knowledge and engagement in general disaster preparedness amongst the population to demonstrate how prepared they are also for nuclear attack.

4.4.1.1. Pre-incident communication preferences

Another aim of this study was to assess the desire for pre-incident information relating to nuclear preparedness following the false alert. The majority of respondents (n=379, 83.5%) appeared to have this desire. Of this sample 90.5% (n=343) reported preferring to receive information any time before an attack is known rather than only when a threat is imminent. Only eight respondents stated that they did not want pre-incident communications as they did not believe that Hawai'i will be attacked with a nuclear device.

Further support for the desire for protection-related information comes from the actions people engaged in when they initially received the emergency alert: only 16% did not seek information about protective actions after receiving the warning. Not only does this indicate a desire for protective information but also a failure in the effectiveness of the warning message itself. This is despite extensive efforts by Hawai'ian authorities, including HI-EMA, in providing preparedness education to the public prior to this time (e.g. HI-EMA, 2017).

In terms of the specific pieces of information that responders reported needing, many requested information about what constitutes an effective shelter and where to go if a nuclear missile was incoming (e.g. "*the best place to shelter within 5 minutes of my work and home"*). This indicated either that many individuals receiving the missile warning were unaware that they can shelter in their own home, did not believe their own home to be an effective shelter from radiation, or both. Without increased public knowledge of sheltering-in-place the public may leave a viable shelter. This is an important issue to be addressed in pre-incident communication.

4.4.2. Adherence

A further aim of this study was to identify the prevalence of behaviours that were deliberately adherent to the instruction to shelter or that were incidentally adherent (i.e. following the guidance or being adherent by virtue of circumstances such as being in bed at the time).

Initial inspection of outcomes suggested that large numbers were adherent to the instruction to "*seek immediate shelter*". However further exploration of the data revealed an important caveat to this. The alert was sent at 8am on a Saturday morning; many participants were adherent to the advice simply because they already happened to be indoors at home (i.e. sheltering) when they received it. Factors that influenced non-adherence with instructions to shelter such as a desire to be with, or to protect loved ones, was reported by between 74(198.83%) to 111(-28.24%) of respondents. This suggest that separation from one's family during the normal working day is likely to result in defiance, or hearing the warning, knowing what is the recommended action, yet choosing not to adhere. Irrespective of time of day, this non-adherence is familiar in hurricane response where people have been found to shelter or evacuate in accordance with instruction, only if able to do so with family (Smith and McCarty, 2009).

Rates of deliberate adherence were associated with few personal variables (being of *other* or mixed ethnicity) and one predictor (believing an attack to be imminent) and appears low in comparison to anticipated adherence rates identified in my review of the literature (Chapter 2). For example, Gerber et al. (2006) found only 33% of US capital region residents were unlikely to comply with sheltering instructions in a nuclear emergency; sheltering instructions in a nuclear plant emergency are likely to inspire less adherence (e.g. 8%: Nyaku, 2014) whilst actual evacuation instruction adherence has consistently been found to be higher (e.g. 54%: Cutter, 1982).

Many of the predictors of adherence or behaviours identified in this study fit with existing models of risk communication. Particularly, lack of awareness of the message and not believing the threat to be real relate directly to Mileti and Fitzpatrick's (1992) first and final stages in the process of shaping risk perception and subsequent behaviour. Mileti and Fitzpatrick's second stage, 'confirm,' can be seen in the most commonly observed behaviour in response to the warning, that of information seeking. Perceived likelihood is a factor in motivating action, found by Mileti and Fitzpatrick to influence interactive searching for information, and subsequently driving decisions of how to respond. Not only this, but risk information is often confirmed when delivered personally and reiterated, perhaps by a social acquaintance. In this survey, confirmation via social acquaintance was a particularly common response; this could also be seen in the many screenshots that alert recipients placed on social media (e.g. Broder van Dyke, 2018; Reinstein, 2018). Those same processes drive the third stage of risk perception forming and behaviour - 'understanding' - and shows that it is not enough to simply warn the public of risk.

Information seeking is undoubtedly a natural response; however, in a nuclear emergency it is unlikely to be a practical one given the short time frame between the public being made aware and needing to act. This emphasises the importance of preparedness since the public are unlikely to rely on a sole source of information regarding such a serious threat. In the event of a real nuclear emergency, the reduced time to impact that exists following this process of information seeking (or other actions such as contacting loved ones) will mean individuals will be left with little time to take other protective actions.

When asked for their reasons for not taking protective action, participants expressed fatalism, denial, uncertainty and lack of awareness. Not only do these closely follow reasons for not being prepared for a nuclear emergency, but they also appear in literature identified in previous chapters of this PhD (e.g. fatalism: Preston, 2014; denial: Alexander and Klein, 2005; lack of awareness: Prezelj et al., 2015) and in my focus groups (lack of consensus). Despite this, most who received the warning acted on it in some way, either by seeking shelter, trying to verify the message, making efforts to find out what protective actions to take, initiating a pre-arranged plan, or attempting to contact loved ones. This certainly suggests that the message had an impact on the population, motivating action of some kind, albeit in many cases, not the desired actions. Other than remaining indoors, 88% did not report acting in a way specifically to protect themselves (i.e. initiating a pre-arranged plan or purposely following the instruction to shelter). This suggests that organisations charged with informing the public of nuclear disaster protections must work to guide the public in issues of preparedness, including how an alert of this kind will look and what it means, as well as providing adequate information in emergency risk communications sent in the event of an attack. Future research of this kind could use hierarchical regression to analyse the variance between different groups for whose survey responses are nested in terms of different levels of preparedness, different demographic profile and previous preparedness education received, for example, to draw greater insight into who adheres to these messages and predictors of that adherence.

4.4.2.1. Belief in message

The next aim was to identify who believed the message to constitute a genuine emergency alert. It may be that believing an attack to be imminent is a stronger motivator of adherence than believing that there is a risk of an attack sometime in the indeterminate future. Indeed, there was a strong association between deliberate adherence and belief that an attack was imminent in this study.

A wide range of factors were associated with believing an attack to be imminent. This included being female, under 40 years old and having children under 18 living at home. Understandably, not believing the warning to have genuinely come from HI-EMA or it being a hoax meant respondents were less likely to believe an attack was imminent. More generally, those who believed that there was a moderate to high risk of a nuclear attack during their lifetime were also more likely to believe that an attack was imminent upon receiving the alert.

It is interesting that there was an association between being first made aware of the threat by hearing the sirens sounding and belief in an incoming missile coupled with subsequent adherence to the instruction in the SMS. This suggests a confirmation effect, relating once again to Miletti and Fitzpatrick's Causal Sequence of Risk Communication. Specifically, if people naturally try to confirm the message, they do not feel the need to when they hear a siren first. Instead they save time and act more quickly. It is with this small sample of respondents that HI-EMA's emergency warning system can be said to have been most effective.

Like adherence outcomes, no association was found between preparedness and belief that an attack was imminent. Scepticism towards threats has been demonstrated before, such as in Rubin and colleagues' (2015) study of swine flu risk communication which suggested white males and older people are more likely to be sceptical. Of course, in this instance, Hawai'ians were right to doubt the message. This may suggest that scepticism in the message is also associated with the nature and familiarity of the hazard. A review of factors affecting preparedness and warning response by Tierney and colleagues (2002) found most empirically supported associations with adherent responses included individual and group-level factors (including knowledge of the hazard) and factors associated with warning messages (including personal communication, message specificity and credibility/familiarity of the source). It is noted that the warnings in Tierney's review varied in recommended action, the agent involved and amount of time that recipients had to respond.

4.4.2.2. Trust in source

The final aim was to assess whether certain variables were associated with adherence and preparedness outcome variables and to gather additional data that would be of use in developing improved communications with the population. One central variable assessed was trust in information sources.

Upon receiving the alert, the most frequently used sources of protective-action information were friends and family, online searching and social media. Although these sources were also used to check the authenticity of the warning, this is interesting as they were also ranked amongst the lowest for trustworthiness. This may tell us that in time poor emergency situations such as this, people will look to maximise the effectiveness of the actions that they take and where possible, in this case, checking the safety of loved ones and looking to receive guidance at the same time. Pre-incident, only one respondent reported that their nuclear-specific preparedness information came from nuclear agencies despite nuclear agencies being rated second highest for trust. Consideration should be given regarding the accessibility and visibility of preferred information sources particularly with the current accessibility of less-trusted social media and online resources.

4.4.3. Limitations

One limitation to consider in relation to this survey is the range of variables that were included. Some variables identified in Chapter 3 (focus groups) as potentially relevant were not tested here. These include perceived efficacy of preparedness actions. This was considered for inclusion, but it was decided that a central aspect of this study, given the context, was adherence to the warning instruction. Despite a generally good level of preparedness in this sample, inclusion of variables related to efficacy of actions may allow for understanding of incidences where low rates of preparedness are observed. Another key outcome from the focus group phase was that preparedness actions are unlikely to be undertaken if perceived effort is high even when risk perception toward the threat is high. This was not explored since so few participants in this study reported having prepared specifically for a nuclear emergency.

Multiple hypotheses were tested in this study, raising the possibility of type 1 errors occurring. This hypothesis testing approach meant that associations between each predictor variable, while adjusting for demographic variables were tested individually. But this does leave open the question of whether these particular variables fully explain preparedness and response of this population. Another approach would have been to combine the variables in a regression model. This would have allowed me to assess the amount of variance in the outcomes that could be explained by these variables such as by generating an R-squared statistic to show the variability of the response data around the mean of the outcome. In logistic regression there is no R square equivalent to demonstrate this. Future iterations of this study might benefit by taking this approach to the analysis.

Other study limitations exist in the form of potential biases. Whilst anecdotally described as a 'flashbulb moment' for many people in Hawai'i, the passage of time may mean that the accuracy of participant's recall of events surrounding the alert was poor. Of perhaps more importance, however, is recall bias. For example, respondents may have retrospectively considered themselves to have been adherent to the instruction to shelter, discounting actual actions taken immediately upon receiving the warning prior to sheltering. Participants may also have been more likely to recall preparedness information received if they then went on to use that information in the event; this could create a misleading impression of how effective the preparedness information they received was. Similarly, participants may not have recalled all relevant preparedness items that they have. For example, a water butt in the garden may contain a 14-day supply of water but might only have been recalled and reported by participants who, for whatever reason, are more focussed on disaster preparedness. A degree of recall bias may also explain why only half of those believing the alert came from HI-EMA also apparently believed there to be an imminent attack – it could be that the benefit of hindsight led some respondents to re-evaluate whether they had really believed the alert at the time.

Selection bias may also be a reason to exercise some caution whilst interpreting these results. The ballistic missile false alert undoubtedly would have caused varying emotional impact on the Hawai'i population that it affected. Not only are those who experienced a particularly intense emotional response potentially the most likely to have responded or changed their behaviour in a particular way. They may also be those more motivated to take part in this survey. Outcomes may therefore be skewed towards certain behaviour or beliefs, such as higher rates of preparedness than that typical for Hawai'ians.

It may also be that certain groups are more likely to respond to an online survey. This can also be linked to the sampling strategy employed during recruitment, which raises a question around external validity: market research participants and university students are not necessarily fully representative of the Hawai'i population and so these outcomes are limited in their generalisability to the wider population.

4.4.4. Implications

4.4.4.1. For Hawai'i civil defence and policy

News and online media reports of the immediate response of the Hawai'i population were conflicting: the missile alert triggered either panic and chaotic scenes (BBC, 2018), or fatalistic acceptance (Hennigan, 2018; Reinstein, 2018) depending on the report. The outcomes of this study suggest that neither was the case. Instead, more measured responses took place: not necessarily following the instruction to shelter, but rather seeking information, either to clarify or verify the warning message or to better understand the actions that should be taken to offer protection. This does however suggest, as articulated by Irwin Redlener, Director of Columbia University's Center for Disaster Preparedness, an "*utter failure to educate the public about what to do in the event of a nuclear detonation*" (Redlener, 2018).

Public preparedness initiatives, particularly those relating to catastrophic emergencies, have been shown to be a double-edged sword. Increased awareness of preparedness and protective actions, in addition to nuclear emergency procedures has obvious benefits to the public who are more educated in actions they might take in preparing for and responding to such an emergency, whilst concurrently increasing a sense of alarm and anxiety in the public. Redlener's advice is to "*go public*" with what we know about protective actions, giving us the best chances of survival, or at least reducing harm. This includes "*remind(ing) people that our society can and would survive a single bomb*". Whilst transparency and honesty of public officials is perhaps the safest way to ensure trust is maintained on the part of the public, if done badly, such as by not considering public wants and needs in communications, it may have the opposite than desired effect, reinforcing fatalistic ideas that survival is not a realistic option and leading to a subsequent disregarding or ignoring of advice.

This study highlights a potential need for providing comprehensive pre-incident communications, firstly in reducing information seeking in the event of an alert being sent. Reports not only from the participants of this study, but also news reports during the days following, show jamming of phone lines and data services (e.g. Boboltz et al., 2018; Hennigan, 2018). This study suggests that the Hawai'i public used phone lines and the internet primarily to verify that the information they had received was accurate and to contact friends and family. Inability to use communication lines may have serious consequences with regards to survival rates, considering the third most commonly cited action taken was to find out how to protect oneself.

The second benefit of effective pre-incident communication regarding disaster protection is again found in both the outcomes of this study and the reports of individuals immediately following the event (e.g. Broder Van Dyke, 2018), and that is ensuring the public know what is meant by key terms such as sheltering. Again, this knowledge will likely increase survival in the event of an actual nuclear disaster; if the public know that their own homes, or the buildings they are in at the time, offer sufficient protection, then adherence with instructions in an emergency may increase.

Only 9% of respondents stated that they felt prepared upon receipt of the ballistic missile warning, though greater numbers reported undertaking preparedness actions, with many participants having received no information specific to nuclear attack preparedness (approximately 50% in this study, compared to only 5% for general disaster preparedness). Additionally, more respondents felt that information received was not sufficient than those who felt it was. Information quality and abundance may not be the sole reason for this deficit in nuclear preparedness, however. Acceptance of information may also play a part. This is supported by the rates of respondents to this study who felt there was little risk of nuclear attack occurring on Hawai'i, and the large number who felt that they could not be protected should an attack occur. Such perceptions may cause individuals to avoid or reject attempts to educate them about nuclear preparedness.

Some organisations that have taken it upon themselves to prepare those in their charge for a nuclear emergency have received criticism. The University of Hawai'i distributed an email to all students in October 2017 directing them towards HI-EMA instructions to shelter-in-place upon hearing warning sirens sounding (Anderson, 2017). Whilst it is routine for the University to send precautionary natural disaster warnings, this is not the case for nuclear attack-related communications. A statement made by the University's communications team was that the word "*unlikely"* should have been placed in the subject line along with "*NO REASON FOR ALARM"*. This suggests two matters of concern for nuclear preparedness communication.

Firstly, it is vital to consider the wording of messages to ensure that there is no ambiguity as to the reason for offering instructions. Perhaps a current level of severity should accompany messages to distinguish between levels of urgency (say, during peacetime and during a time of known threat).

The second factor is harder to address: at present, safety information specific to nuclear threat is not commonplace. Government agencies are often loath to place information in the public domain that could cause distress. For example, one Hawai'i-based website reported in September 2017 that local lawmakers had met without inviting the public to discuss ways in which the public could be helped to prepare for nuclear attack "*without fear-mongering*" (Teague, 2017). It is notable however that HI-EMA, on the Hawaii.gov website posted links to external news sites containing videos such as "*How Honolulu is preparing for a Nuclear Strike,*" comprehensive FAQs and a summary of guidance for coordinated public messaging in the event of nuclear detonation amongst other resources both prior to and following the false alert (http://dod.hawaii.gov/hiema/category/nuclear-threat/). It may be that the false missile alert, and the ways in which the public responded to it, will increase the perceived need for preparedness in the public as well as in government. If so, existing preparedness information such as that detailed above will become more widely known as a matter of course. However, findings of Karl and Lytle (2018) in the months following the incident indicated that more than half of US citizens had still received no nuclear attack preparedness information in the months following the false alert, suggesting this to not be the case so far.

It is inevitable that a false alarm will create issues amongst the public towards responding authorities with regards to trust. Will future alarms be taken seriously? Will people trust HI-EMA, or their government as a whole, to provide warnings and effective response if this event actually happened? Two interesting outcomes from this survey provide some answers.

The first is that despite just over half of respondents believing an attack to be imminent, almost 70% believed the alert to have been a genuine HI-EMA alert. This suggests an element of doubt amongst the public with regards to the accuracy or proficiency with which HI-EMA were operating even at that time.

The second is that HI-EMA was ranked as highest in trustworthiness as a source of nuclear preparedness information amongst twelve potential sources. This suggests that trust in HI-EMA has not been overly damaged. The Hawai'i public may even find some reassurance in the knowledge that there is a functional emergency warning system in place (Preston, 2018).

4.4.4.2. For this PhD

Most respondents in this study reported a desire to receive pre-incident communications regarding preparedness and protective actions in the event of a nuclear emergency. It is notable that this does not correspond with the consensus of focus group participants in the previous phase of this project. One obvious reason for this discrepancy is that focus group participants had not experienced a situation in which they believed a nuclear threat to be real and imminent, or at least had never received emergency risk communications to that effect. The next phase of this project will replicate questions asked to the Hawai'i public using the same survey methodology but with a sample from the UK public who have not experienced an existential threat of this nature.

The focus groups also highlighted a lack of preparedness in respondents. Though focus group participants all lived in areas of potential risk (nuclear power plant accidents or terror attacks), these risks were considered low-likelihood. More Hawai'i survey respondents appear to have undertaken at least some preparedness actions but were living in a location which is at arguably greater risk of disaster, such as volcanic eruption or hurricane. Hawai'ians may therefore be exposed to greater volumes of general disaster preparedness information, or actively seek such information out, perhaps driven by increased risk perception. Without having been made salient in the UK, nuclear risk perception may be lower, making the perceived need for pre-incident communications lower in priority.

One interesting thing explored in this study was the interplay between belief in the authenticity of message and adherence with the instruction to shelter. An interesting sub-group here are those who reported that they did believe, but nonetheless did not act. Further sub-analysis could have given insight the motivating factors influencing this decision.

Finally, Hawai'i was in the process of testing their nuclear emergency warning system of sirens in the months preceding January 2018. This may have increased risk perception, driving an increase in preparedness activities. Without knowledge of the existence of a public emergency warning system in the UK it would be interesting to observe whether risk perception is higher or lower in UK respondents.

4.5. Conclusion

Popular perceptions of the Hawai'i public's response to what was revealed to be a false alert warning of imminent nuclear attack, was of panic and disorder. This is not an accurate portrayal of responses. However, a range of behaviours and attitudes were present that are consistently described in radiation-disaster literature; such as non-adherence to the warning instruction and fatalism. The predominant reaction, to contact friends and family and seek further information, despite relatively high rates of preparedness suggests a failure to provide the public with effective pre-nuclear incident risk communications. Outcomes of this survey can be used to inform the design of pre-incident communications, likely to improve adherence to critical instructions in the event of a nuclear attack.

Chapter 5: Survey with Members of the UK Public

Whereas the survey outlined in the previous chapter, undertaken with the Hawai'ian public focussed particular attention on behavioural response to the ballistic missile warning, the survey undertaken in this chapter, with the UK public, presents an opportunity to focus on the pre-incident communication and preparedness aspect of nuclear catastrophe. It achieves this while also providing some areas where comparison can be made with a population who recently experienced the potentially real prospect of existential crisis, with a population who have not had such an experience. Particularly, this survey was also an opportunity to build on knowledge gained from focus groups, including the role that perceived efficacy of recommended countermeasures plays on behaviour. This survey provides important insights into perceived effort and effectiveness of what are recommended protective actions and the influence of perceived risk on adherence to undertaking these actions.

5.1. Background

The previous chapter reported on a survey conducted with members of the Hawai'i public. This followed the false ballistic missile alert that occurred in that state in January 2018. That research was an opportunity to gain insight as to how members of the public might respond to the possibility that a nuclear attack is imminent, including rates of adherence with protective instructions and the level of success of the method by which the warning and instruction was distributed (SMS). Preparedness for nuclear emergencies was also assessed together with pre-incident information preferences. These data suggest ways to improve engagement with nuclear emergency pre-incident communications.

The main outcomes from the Hawai'i survey were that most respondents had not undertaken recommended preparedness actions specifically for nuclear attack, though many had for reasons of general preparedness or preparedness for an alternative disaster. Following the alert, deliberate adherence with the instruction to shelter was low, however due to situational factors such as the time and day of the warning, many respondents were already at home and remained there. Low deliberate adherence was influenced by disbelief that the warning or attack was genuine and belief that no effective protective measures from a nuclear attack exist. Demographic and situational factors were associated with believing the warning to be genuine (including believing there to be a moderate to very high risk of a nuclear attack against Hawai'i occurring) and taking subsequent protective actions. These included being of mixed ethnicity, hearing warning sirens as the first indication of an attack and believing Hawai'i to be protected from nuclear attack by the military. Respondents were motivated to take action by a wish to verify the message received, to protect their family and through feeling unprepared. Preferences were also expressed for pre-incident communications to be delivered to the public during a period when no threat is known (not only when a threat is imminent) and to include information as to what makes an effective shelter, what to prepare and how supplies (food and water) and infrastructure (communications) might be affected in a nuclear disaster.

Those outcomes are contrary to some outcomes of previous chapters in this thesis. UK participants of focus groups (Chapter 3) expressed little preparedness, whether living near a nuclear power plant or in London, due to low perception of risk. In fact, amongst other factors including geography, nature of the threat and trust in information source, risk perception was felt to be a stronger influence on adherence with instructions than the actual information received. Specifically, those expressing low risk perception considered themselves less likely to engage with preparedness information, while high risk perception individuals held fatalistic attitudes prompting avoidance of information. Groups also felt that recommended protective actions should only be sent when a nuclear disaster was known to be imminent, expressing little desire for pre-incident preparedness information, again due to low risk perception. Some focus groups differentiated between the likelihood of a nuclear attack occurring against the UK and it having a direct personal consequence, such as injury to the self or loved ones, and the likelihood of an attack occurring but it not affecting them. This form of perceived likelihood represents a subset of risk perception wherein risk equals perceived likelihood x severity (e.g. Tversky and Kahneman, 1974) and deserves further exploration in this survey. Perceived likelihood of a nuclear attack (belief that an attack is likely but that it will not necessarily cause them harm) was suggested not to influence behaviour change.

Similarly, the systematic review (Chapter 2) showed varying adherence in actual radiation emergencies. Adherence was found to reduce if the event is considered unlikely to occur, if risk of direct harm is considered low (Gibson, 2007; Železnik and Perko, 2012), if recommended actions are felt to be ineffective (Rogers et al., 2013; Taylor et al., 2011), or if the individual is fatalistic (Nasar and Greenberg, 1984). While the public appear more adherent to protective instructions according to review outcomes than was observed in Hawai'i, three notable factors undermine this comparison: adherence rates identified in the systematic review related to nuclear plant disasters or smaller-scale radiation emergencies (dirty bombs); actual adherence was assessed in terms of evacuation, as opposed to sheltering, and; there is also the issue of uncertainty of the incident since some of the actual incidents in the review involved the disaster observably being underway whereas in Hawai'i it was not clear if it really was or not. The present survey explored whether a difference exists in intention to engage in preparedness actions at a time of no known threat as well as intended adherence with protective actions if an attack is imminent.

The present survey employs substantially the same methods as used in the previous chapter, but with a sample of the UK public. This allows for comparison with outcomes of the previous chapter for the following reason. In months before the false alert, tensions between the USA and North Korea, two nuclear powers, were at a peak. In fact, shortly before the false alert, North Korea announced a new capability for its ballistic missiles to reach the Hawai'ian Islands. Hawai'i itself had reaffirmed its emergency warning capability during the final months of 2017 by publicly testing its warning sirens. The UK by contrast has received no such direct threats in recent history, nor has there been a recent public initiative to establish current civil defence capability. While there is an existing requirement in the Civil Contingencies Act 2004 to inform the public as to disaster preparedness measures, studies have shown that initiatives to meet this requirement have been tokenistic, with many not aware and others not having read the information disseminated (e.g. Page et al., 2008). Risk perception may therefore differ substantially between the two populations. This may affect rates of preparedness and desire for pre-incident information.

Repeating the survey in a sample of the UK public allowed me to refine the survey tool and test additional hypotheses. Two questions were added to the collection of demographic information. Firstly, Hawai'i respondents were not asked whether they were pet owners. While there are consistent findings that parents would ignore or delay protective actions in a nuclear emergency to be with or to contact their children (Nasar and Greenberg, 1984), no similar findings were identified in radiation emergency literature for pets. However, it is possible that pet owners have additional needs regarding nuclear attack preparedness. Secondly, a question of residential region was added. Hawai'i respondents were often fatalistic, feeling that they had no means of surviving a nuclear attack due to their geographic location (i.e. island-dwelling). Focus groups conducted with the public living in or close to London and with those living near to a nuclear power plant (Chapter 3) built upon outcomes from the systematic review (Chapter 2), finding little perception of risk from the nearby plant. London residents appeared to express slightly greater risk perception of both nuclear attack and of being affected by a nuclear plant accident, but not enough to affect desire for pre-incident communications or to increase preparedness to any significant extent. Including region as a demographic variable may provide an indication of whether Londoners have greater risk perception and subsequently express a greater need for pre-incident information, or less need perhaps due to fatalistic attitudes.

Whilst the perceived effort involved in preparedness and protective actions was included in the previous survey, perceived efficacy of actions was not assessed. Efficacy was a central outcome from focus groups in which participants felt they had little control over their ability to effectively undertake protective actions. In particular, if recommended actions were felt to be ineffectual then fatalistic attitudes appeared to increase and engagement with information and anticipated adherence decreased. This suggests an assessment is made by the recipient of communications as to the trade-off between the effort involved in preparedness or change in lifestyle with the relative risk of harm that a nuclear attack poses. Whilst it is acknowledged that efficacy (the extent to which the action does more good than harm under *ideal* circumstances), by its most strict definition, differs from effectiveness (the extent to which the action does more good than harm under *usual* circumstances) (e.g. Kim, 2013). The word effectiveness was used due to its likely greater ease of understanding. Perceived effectiveness is important to consider since adherence with protective instructions may be reduced if recommended actions are perceived ineffective (Rogers et al., 2013; Taylor et al., 2011); a key outcome from the systematic review.

5.1.1. Objectives

1. (aligning with the first of the project aims) identify the proportion of people who a) possess adequate materials to allow them to cope with a nuclear disaster, b) possess these materials specifically due to a concern about nuclear disasters and c) are prepared out of a concern for general emergencies;

2. (aligning with the first of the project aims) to assess whether the following variables were associated with disaster preparedness:

- perceived risk to self and loved ones of a nuclear attack against the UK (and perceived likelihood of an attack occurring and it not affecting them);
- perceived risk to self and loved ones of an unspecified disaster in the UK (and perceived likelihood of a disaster occurring and it not affecting them);
- how much preparedness information they had previously received;
- perceived information sufficiency;
- their level of faith in the UK's defence capabilities;
- the perceived level of effort involved in taking preparedness measures (such as storing items) and effectiveness in sheltering, as is recommended in nuclear disaster preparedness guidance, and;
- Demographic variables.

3. (aligning with the second of the project aims) To identify factors that promote anticipated engagement with pre-nuclear incident communications, including:

- timing (whether during peacetime or when a threat is known/raised);
- source of the communications;
- method and format by which communications arrive (i.e. online or leaflet; from government official, nuclear expert or other), and;
- perceived risk perception of a nuclear disaster occurring during their own lifetime, and the risk of this having a direct impact upon themselves or their loved ones.

5.2. Method

5.2.1. Design

This study was conducted using an online, cross-sectional survey sent to members of the UK public. Theoretical Domains Framework was used to inform items for inclusion.

5.2.2. Participants

Participants were recruited by commissioning a UK market research company. Participants received tokens which contributed toward an eventual monetary reward. Members of the public were invited to take part if they were UK resident and were over 18 years.

5.2.3. Materials

An online survey was developed based on the items included in the survey deployed to members of the Hawai’i public (Chapter 4). The survey was hosted and distributed by a market research company. It included forced choice questions (some of which were free text but requiring some kind of written response) relating to disaster preparedness and pre-incident communication preferences amongst other items. The full survey items are in Appendix M.

5.2.4. Outcome variables

5.2.4.1. Preparedness

Respondents were asked to select all preparedness actions they had taken. Listed actions were taken from Protect and Survive (HMSO, 1980) and from FEMA’s most recent information sheet published in March 2018. Actions included storing a spare supply of medication; storing a 14-day supply of food and water; obtaining a torch and batteries; putting together a first aid kit; and storing a bag with cash and important documents. Obtaining walkie-talkies was included in the Hawai’i survey but removed as a response option here as they are not recommended preparedness items in UK guidance. For each action endorsed, and because a number of items listed as necessary for preparedness such as a torch with batteries and band aids are those often possessed for non-preparedness reasons, respondents were asked to detail their reason for undertaking this action (specifically for nuclear attack preparedness; in case of a different specific emergency such as flooding; for general emergency preparedness; or not for emergency preparedness purposes).

5.2.4.2. Pre-incident information preferences

Respondents were asked whether they wished to receive pre-incident information relating to preparedness for, and protective actions to take in the event of, a nuclear attack. Those who responded yes to this question were directed to a further question asking when would be their preferred time to receive information (during a period of low threat, or only when a threat is known to be imminent). Those who responded no to this question were asked why not. Response options for why not included: I would be too afraid and I don't believe I could be protected if the UK was attacked.

In the Hawai'i survey, participants were asked what two pieces of information would you most want to know in nuclear emergency preparedness materials? This elicited a large amount of qualitative data. The intention of the survey phase in this project was to bring focus to previously identified qualitative outcomes (i.e. those elicited in focus groups). The question requiring respondents to provide two pieces of information critical for pre-incident information was retained, however using the outcomes from the previous survey, focus group and systematic review chapters, a list of forced choice outcomes was formulated. Response options included information about: sheltering; evacuating; how to prepare in advance for a nuclear emergency; radiation; how information about an incident will be delivered; information specific to nuclear accident; information specific to a deliberate nuclear incident; how to prepare for emergencies more generally or something not listed (open text response).

Preferred methods of pre-incident communication distribution were not assessed in the previous survey. Importantly, methods including social media and the internet have been found to be preferred to SMS in the event of an attack and traditional news media or leaflets for pre-incident information. Participants in this survey were asked by what method(s) would they prefer to receive information regarding nuclear disaster preparedness? Response options included internet/online, a letter posted to their residence and at a local council meeting.

Similarly, preferred information source, or specifically, the likelihood of undertaking preparedness and protective actions depending upon the communicating information source were included in the present survey.

5.2.5. Predictor variables

5.2.5.1. General

Upon consultation with members of the project advisory team, the following updates were made to reflect contemporary knowledge and emergency preparedness beliefs of the public:

a. Questions relating to protective actions that might be taken were updated to remove the word *evacuation.* This was following a suggestion that respondents may see evacuation as something that is forced upon them. Instead the response option asked whether the respondent was prepared to leave their home.
b. Distinction was made between sheltering (simply staying indoors) and using furniture and other items to build a shelter. The suffix -*in-place* was also removed from *shelter* as its meaning is not always known.
c. The response option: if an attack happened, the government would provide us with everything we needed, was added to the list of reasons for not wishing to receive pre-incident communications.

5.2.5.2. Risk perception

Participants were required to answer questions relating to their perceived likelihood of the following: a catastrophic disaster of any kind (e.g. severe flooding, earthquake, attack from foreign military) occurring anywhere in the UK within your lifetime; a catastrophic disaster of any kind (e.g. severe flooding, earthquake, attack from foreign military) occurring in the UK within your lifetime AND it directly affecting the health of you and/or close family members; a nuclear attack by another country or terrorists occurring anywhere in the UK within your lifetime; and, a nuclear attack by another country or terrorists occurring in the UK within your lifetime AND it directly affecting the health of you and/or close family members.

Another question asked if they believe the UK to be protected from nuclear attack by military intervention.

5.2.5.3. Prior information received

Retained survey items included preparedness information received. This was the amount of preparedness information previously received; how long since information was received; from what source did the information come and; perceived information sufficiency. An addition was made asking the level of general disaster preparedness information previously received. Information source response options were updated to reflect sources likely encountered by UK residents. Respondents were also able to select multiple sources. Response options for these items are shown in Appendix M.

5.2.5.4. Perceived preparedness effort

Participants were asked to rate the perceived effort involved in carrying out individual actions listed in the earlier preparedness question with addition of the following: watch preparedness videos online; be prepared to shelter (e.g. at home) for up to 72 hours; be prepared to shelter (e.g. at home) for up to 1 week; be prepared to shelter (e.g. at home) for up to 2 weeks; be prepared to leave your home to a place of shelter within your town or village and; be prepared to leave your home to a place of shelter outside of your town or village.

5.2.5.5. Perceived effectiveness

Participants were asked how effective they feel listed actions would be in protecting them should a nuclear attack occur 5 miles from where they are. Response options were: sheltering (i.e. remaining inside); building a shelter from furniture (e.g. in your own home); leaving your home to a destination as far away as possible; leaving your home to a shelter elsewhere in your location (such as the outskirts of town); taking Stable Iodine (a tablet used to prevent radiation damage in the thyroid); getting underground (e.g. into a basement) and; closing doors and windows at your location.

5.2.5.6. Trust

To identify the most trusted sources of nuclear preparedness information, participants were presented with twelve sources (including national government, nuclear agencies; local authorities and emergency services). Using the same list of response options, participants were asked: how likely are you to undertake preparedness actions (i.e. during a time whilst there is no known threat) for a nuclear attack if advised to by each of the following sources? And: how likely are you to undertake protective actions (i.e. if threat of attack is known to be imminent or immediately following an attack) for a nuclear attack if advised to by each of the following sources?

5.2.5.7. Demographic variables

Participants were asked to state their gender and age for which representative ratios were taken from a national proportion calculator belonging to the market research company which provides nationally representative data per country. Quotas for geographic location were also taken from this calculator, response options for which were based on UK government organisation regions. Further demographic data were taken for employment status and educational attainment. Participants were asked whether they have pets or dependent children, response options for the latter were: no; I have a dependent child/children aged under 18 living with me; I have a dependent child/children aged over 18 living with me, and; I have a dependent child/children under 18 but they do not live with me.

5.2.6. Procedure

The survey was distributed via e-mail to individuals who formed part of a market research participant database. Interested individuals were able to follow an anonymous link using any internet enabled device to access survey information. Providing they indicated consent, respondents were then able to participate in the survey. The survey became available on March 1st, 2019 and met the required sample size after eight days.

5.2.7. Ethical considerations

Approval for the study was granted by the King's College London Psychiatry, Nursing and Midwifery Research Ethics Subcommittee (ref: HR-17/18-8256).

5.2.8. Sample size calculation

Based on a UK population of 66.04 million (Office for National Statistics, 2018), to obtain a 95% confidence level with 3% margin of error a sample size of 1000 completed responses was required according to surveymonkey.com.

5.2.9. Outcomes and analysis

Responses were recorded on an Excel (Microsoft) spreadsheet and imported into SPSS Version 25 (IBM) for statistical analysis.

Some outcomes required re-categorisation for comparative significance testing. Where re-categorisation occurred, it is detailed below.

5.2.9.1. Preparedness

Because there is a potential difference in the factors associated with whether someone consciously engages in actions to prepare for a disaster, and whether they engage in actions that, by accident or coincidence, make them prepared (e.g. collecting camping gear), the sample were split, based on why preparedness actions had been undertaken. This allowed for ‘intentional’ and ‘incidental’ disaster preparedness scores to be calculated (0 to 7 actions). General disaster preparedness outcomes were included in this analysis since few people reported taking preparedness actions specifically for nuclear preparedness. For intentional preparedness, a median split was used which and categorised people reporting zero to two intentional preparedness actions as having low intentional preparedness, and those reporting three to eight actions as having high intentional preparedness.

Binary logistic regression was used to test associations between intentional preparedness and personal and predictor variables. Predictor variables included were: general disaster likelihood; risk perception of general disasters occurring and directly affecting the self or loved ones; nuclear attack likelihood; risk perception of nuclear attack occurring and directly affecting the self or loved ones; prior level of disaster preparedness information received; prior level of nuclear preparedness information received; source of preparedness information; how recently preparedness information was received; perceived sufficiency of preparedness information received; belief in protection from the military; mean average low preparedness effort scores; mean average high preparedness effort score and; perceived effectiveness of sheltering. Unadjusted odds ratios are displayed in Appendix N. Linear regression was used to test associations between ‘absolute’ (total) preparedness and prior level of general disaster preparedness information received; prior level of nuclear preparedness information received; source of preparedness information; how recently was preparedness information received; whether preparedness information was considered sufficient; belief in protection from military; low preparedness effort scores and; high preparedness effort score.

5.2.9.2. Pre-incident communication preferences

Using binary logistic regression, adjusted odds ratios were calculated (adjusted for demographic variables) for associations between desire for pre-incident communications and the following personal and predictor variables: general disaster likelihood; perception of general disasters occurring and directly affecting the self or loved ones; nuclear attack likelihood; perception of nuclear attack occurring and directly affecting the self or loved ones; prior level of disaster preparedness information received; prior level of nuclear preparedness information received; source of preparedness information; how recently preparedness information was received; perceived sufficiency of preparedness information received; belief in protection from the military; average low preparedness effort scores; average high preparedness effort score and; perceived effectiveness of sheltering. Unadjusted odds ratios are displayed in Appendix O.

5.2.9.3. Preparedness effort and effectiveness

Effort was rated on a ten-point scale (1 = very little to no effort involved; 10 = much more effort than I would be prepared to take) and effectiveness on a seven-point scale (1 = not effective at all; 7 = extremely effective).

To reduce the data and simplify the analysis, I used principal components analysis to identify whether an underlying structure existed for the preparedness items. These were recategorized as 0 (low effort actions) and 1 (high effort actions). Also included in the PCA was preparedness effectiveness. Outcomes are presented in the scree plot and pattern matrix below.

5.2.9.4. Perceived disaster likelihood

Questions were scored on a 10-point scale from 1 (Definitely will not happen in my lifetime/not directly affect me) to 10 (Definitely will happen in my lifetime/would directly affect me). Differences in mean average scores were analysed using a t-test. To draw comparison with outcomes from the Hawai'i survey, scores were re-categorised as follows:

> 1-2 = No risk at all; 3-4 = a little risk; 5-6 = moderate risk; 7-8 = quite a high risk; 9-10 = very high risk/ quite probable

These outcomes are tabulated in Appendix M.

5.2.9.5. Source and preparedness rankings

Average ratings across all respondents were calculated for trust in listed information sources, anticipated likelihood of preparedness and anticipated likelihood of protective actions. Responses were rated on a ten-point scale (for anticipated likelihood: 1 = extremely unlikely; 10 = extremely likely; sources were ranked in the order most trusted from 1 - 12).

5.2.9.6. Demographic variables

Due to low numbers in some demographic categories recoding was undertaken to consolidate groups. Specifically, employment was recoded into either employed or not employed; geographic locations were consolidated into London and outside of London locations, and; parental status was re-categorised as none, children <18 living with me, children >18 living with me and children not living with me.

5.2.9.7. Thematic analysis

Open text responses were analysed thematically (Braun and Clarke, 2006). This involved generating initial codes upon reading the data, extracting themes that arose and reporting these with reference to the pre-defined outcome variables. Questions with *other* response options required open text elaboration. These were: which from the list (of preparedness items) do you currently have?; What 2 pieces of information would you most want to know in nuclear emergency preparedness materials?; Where did (your preparedness) information come from?; By what method(s) would you prefer to receive information regarding nuclear disaster preparedness? And; why would you not wish to receive information regarding preparedness and protective actions prior to a nuclear attack?

5.3. Results

5.3.1. Demographics

There were 1014 completed responses to the survey. This was a response rate of 43%. The sample was broadly representative of the UK population as shown in Table 5.1, with the exception that it appears to have slightly more male respondents, 18-29 year olds (the youngest age group), unemployed, people with higher qualifications, retired and disabled. Individuals without qualifications appear under-represented according to the 2011 UK census (Office for National Statistics, 2011). Most respondents reported having no children (67%) with almost a quarter having a child/children under 18 years old living with them. Slightly above half of respondents were pet owners (53%).

Table 5.1. *Demographic profile of survey respondents*

Demographics	Frequency	%	Population %
Gender			
Male	503	49.6	49
Female	507	50	51
Non-binary gender	2	0.2	
Prefer not to say	2	0.2	
Total	1014		
Age			
Between 18-29 years old	166	16	20
Between 30-39 years old	163	16	17
Between 40-49 years old	176	17	17
Between 50-59 years old	185	18	17
Between 60-69 years old	168	16.5	14
70 years or above	155	15	15
Prefer not to say	1	0.1	
Total	1014		
Dependent Children			
No	675	66.5	57
I have a dependent child/children aged under 18 living with me	234	23	20
I have a dependent child/children aged over 18 living with me	53	5	-
I have a dependent child/children aged under 18 not living with me	24	2	-
I have children under and over 18 living with me	23	2	-
I have children both living and not living with me	5	0.5	-
Total	1014		
Pets			
Yes	538	53	50
No	476	47	50
Total	1014		
Employment Status			
Employed, working 40 hours or more per week	307	30	55
Employed, working 1-39 hours per week	254	25	20
Not employed, looking for work	49	5	6 (overall unemployed)
Not employed, not looking for work	83	8	-
Retired	270	27	2.8
Disabled, not able to work	50	5	0.8
Total	1014		
Education			
Left school without qualifications	59	6	23
Secondary education	466	46	50
Higher education	488	48	27
Prefer not to say	1	0.1	-
Total	1014		
Geographic Region			
Wales	48	5	5
Scotland	90	9	8
Northern Ireland	27	3	3
North East	40	4	4

North West	106	10	11
Yorkshire and the Humber	92	9	8
East Midlands	70	7	7
West Midlands	91	9	9
East	99	10	10
London	125	12	13
South East	145	14	14
South West	81	8	8
Total	1014		

5.3.2. Preparedness

Table 5.2 shows the number of participants who had engaged in each preparedness activity. Preparedness actions most commonly reported were having obtained a torch and extra batteries (80%) and having put together a first aid kit (74%). The least frequently reported action was storing cash and important documents (25%). *Other* preparedness items reported by respondents were categorised into the following themes: *Clothing and comfort; Food and drink; Fuel, Heating and power; Security; Electronics,* and; *Miscellaneous*. Clothing was the most frequently cited *other* item and aligned often with camping and bedding equipment. Unspecified amounts of food (mostly tinned) and water (and water filtration) were also commonly reported, less so were items for fuel (petrol), portable heating equipment and portable stoves which were stored by participants in equal measure. Weapons and electronics were occasionally reported (knives, mobile phones and chargers most commonly). Miscellaneous items primarily included tools (including excavation equipment such as spades) and items for survival which included outdoor survival kit, information on what to do, a plan (e.g. for evacuation), books on survival and emergency contacts.

Table 5.2. *Summary of preparedness actions taken*

Action	**% within category: Nuclear attack preparedness (N)**	**% within category: Other, specific emergency preparedness (N)**	**% within category: General emergency preparedness (N)**	**% within category: Non-emergency reasons (N)**	**Total % (overall N)**
Obtained a torch (and extra batteries)	1 (12)	10 (85)	59 (483)	29 (233)	80 (813)
Put together a first aid kit	1 (11)	9 (68))	65 (486)	24 (182)	74 (747)
Stored a spare supply of medication	3 (13)	14 (56)	65 (263)	17 (70)	40 (402)
Obtained a battery powered radio	4 (14)	10 (40)	46 (178)	39.5 (152)	38 (384)
Stored a 14-day supply of food/water	3 (12)	14 (51)	52 (183)	30 (106)	35 (352)
Stored a bag with cash and important documents	5 (12)	16 (41)	55 (136)	24 (60)	24.5 (249)
Other	4 (5)	20.5 (24)	58 (68)	17 (20)	11.5 (117)

The scree plot (Figure 5.1) representing principal components analysis output suggested loading of perceived preparedness effort and effectiveness onto three factors (notably however this method did not reduce the data for effectiveness). This was confirmed through analysis of the pattern matrix output (Table 5.3). Main loadings on component one were preparedness actions rated as requiring the least effort. Component two was made up solely of the protective actions to which participants were asked to rate effectiveness. Component three comprised the five preparedness actions rated most highly for effort.

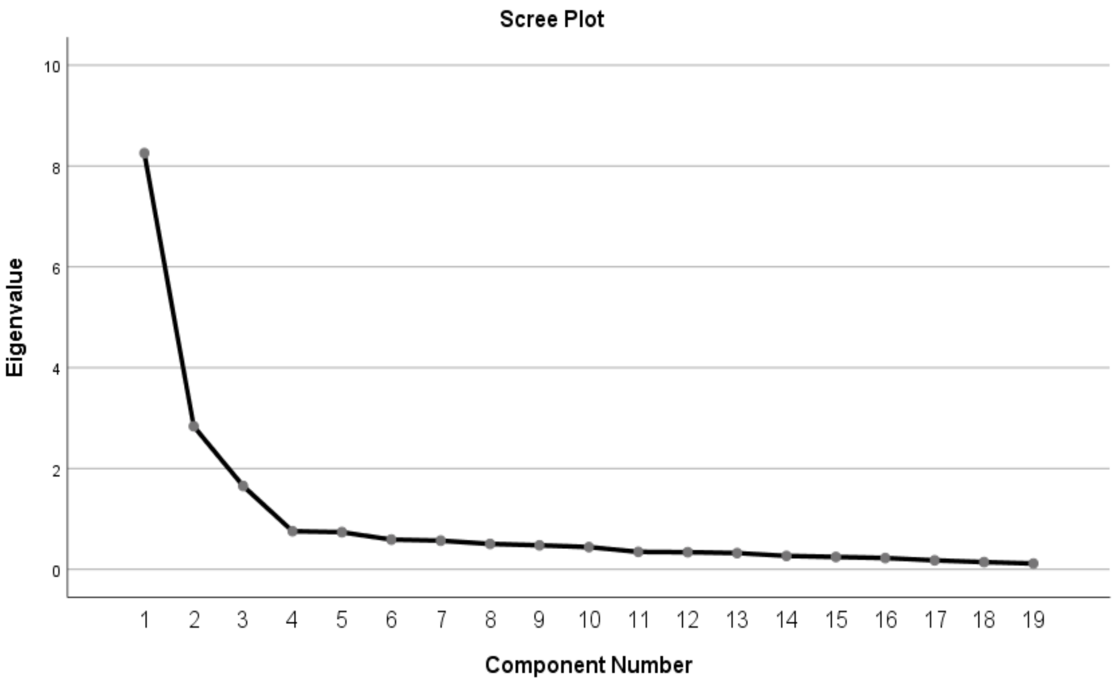


Figure 5.1. Scree plot output of principal components analysis of perceived effort of undertaking preparedness actions and perceived effectiveness of protective actions

Table 5.3. *Pattern matrix output of principal components analysis of perceived effort of undertaking preparedness actions and perceived effectiveness of protective actions*

	Component		
	1	**2**	**3**
Preparedness Effort: compile a first aid kit	0.907		
Preparedness Effort: obtain battery powered radio	0.890		
Preparedness Effort: obtain a torch (and extra batteries)	0.855		
Preparedness Effort: store medication	0.755		
Preparedness Effort: store cash/documents	0.706		
Preparedness Effort: watch an online video	0.694		
Preparedness Effort: store (14 days) food/water	0.650		
Preparedness Effectiveness: shelter elsewhere within location		0.836	
Preparedness Effectiveness: evacuate as far away as possible		0.805	
Preparedness Effectiveness: get underground		0.791	
Preparedness Effectiveness: sheltering		0.745	
Preparedness Effectiveness: take stable iodine		0.745	
Preparedness Effectiveness: close doors and windows		0.731	
Preparedness Effectiveness: build a shelter from furniture		0.679	
Preparedness effort: be prepared to evacuate out of town			0.921
Preparedness Effort: evacuate within town			0.847
Preparedness Effort: shelter for 2 weeks			0.811
Preparedness Effort: shelter for 1 week			0.731
Preparedness Effort: shelter for 72 hours	0.408		0.493

Components in this analysis relating to high and low effort preparedness activities were compared using a paired samples t-test. This confirmed that respondents considered high effort preparedness actions (mean=5.35) to be significantly more effort than the low effort group (mean=3.65) (t=--28.65 (df=1013), p<.000).

Participants ranked being prepared to leave their home to a place of shelter outside of town as the most effortful preparedness action and obtaining a torch (and extra batteries) as the least effortful (Table 5.4).

Table 5.4. *Perceived Effort in Undertaking Preparedness Actions*

Rank order of perceived effort (most to least effort)	**Action**	**Mean score**	**Standard Deviation**
1	Be prepared to leave your home to a place of shelter outside of your town or village	6.42	2.41
2	Be prepared to leave your home to a place of shelter within your town or village	5.69	2.44
3	Be prepared to shelter (e.g. at home) for up to 2 weeks	5.39	2.64
4	Be prepared to shelter (e.g. at home) for up to 1 week	4.69	2.55
5	Be prepared to shelter (e.g. at home) for up to 72 hours	4.57	2.68
6	Store a 14 day supply of food/water	4.57	2.57
7	Store a spare supply of medication	4.13	2.52
8	Watch preparedness videos online	3.90	2.50
9	Store a bag with cash and important documents	3.69	2.43
10	Put together a first aid kit	3.41	2.48
11	Obtain a battery powered radio and spare batteries	3.10	2.39
12	Obtain a torch (and extra batteries)	2.76	2.31

1 = very little to no effort involved; 10 = more effort than I would be prepared to take

Participants ranked getting underground as the most effective protective action to take should a nuclear attack occur five miles from them and building a shelter from furniture as least effective (Table 5.5).

Table 5.5. *Perceived effectiveness of protective actions*

Rank order of perceived effectiveness (most to least effective)	**Action**	**Mean score**	**Standard Deviation**
1	Getting underground	3.58	1.96
2	Leaving your home for a destination as far away as possible	3.58	2.03
3	Leaving your home for a shelter elsewhere in your location	2.98	1.91
4	Taking Stable Iodine	2.82	2.17
5	Sheltering	2.74	1.87
6	Closing doors and windows at your location	2.67	1.88
7	Building a shelter from furniture	2.29	1.80

1 = not effective at all; 7 = extremely effective

5.3.2.1. Level of preparedness

An absolute preparedness score (sum of preparedness actions taken, scored 0 - 7) was calculated for each respondent. A mean of 3.02 preparedness actions were reported to have been taken.

Participants had taken a mean of 2.21 actions specifically in preparation for an emergency (intentional preparedness), significantly more than the 0.81 (mean) actions for non-emergency (incidental) reasons ($t= 16.47$ ($df=1013$), $p>0.0001$).

5.3.2.2. Reasons for preparedness

Each preparedness item was reported to have been collected or performed primarily for general disaster preparedness purposes. Each item was possessed specifically for nuclear attack preparedness by between 12-14 respondents only (five *other* preparedness items were stored for nuclear attack preparedness: unspecified amounts of food and water (x3); weapons/tools (*"survival knives"*); *"information of what to do;"* and clothing).

76% of respondents report having received no information regarding general emergency preparedness, whilst 80% had received no information specifically for nuclear attack (8% had received some information). The most frequently reported sources of preparedness information were social media (12%) and friends/family (12%); national news media and national government (11% each) were the next most common. *Other* sources included education (general disaster and nuclear preparedness information).

Information was reported by 45% to have been received between one and five years previously. Disaster preparedness information received was felt to be sufficient by slightly more than 50% of respondents, whilst 13.5% reported not knowing if the information was sufficient.

Logistic binary regression was conducted to identify associations between intentional preparedness and personal or predictor variables (Tables 5.6 and 5.7). Though rates of intentional preparedness for some groups are low, and so outcomes should be considered with some trepidation, participants were significantly more likely to be intentionally prepared if having children under 18 years old living with them or having children not living with them; believing there to be a very high risk of an unspecified disaster occurring during one's lifetime, or there being a moderate to very high risk of a disaster occurring and it personally affecting themselves or loved ones; believing there to be 'quite a high risk' of a nuclear attack occurring on the UK during one's lifetime, or there being a moderate to very high risk of nuclear attack occurring on the UK and it personally affecting themselves or loved ones; having received disaster preparedness information from emergency services; believing preparedness actions to be of low effort and; believing sheltering to be an effective protective action. Respondents aged 40-49; those without pets; those who reported having received little or no general disaster preparedness information, or little to no nuclear attack specific preparedness information; not believing, or not knowing if preparedness information received was sufficient; believing the UK to be partially protected from nuclear attack, not believing the UK to be protected, or not knowing if the UK is protected were less likely to be intentionally prepared.

Table 5.6. *Association between personal variables and intentional preparedness*

Variable and variable levels	% (N) of participants	% within variable level (N) classified as intentionally disaster prepared	Intentional preparedness adjusted odds ratio (95% CI)
Gender			
Male	50 (503)	41 (205)	*Reference*
Female	50 (507)	40 (201)	0.94 (0.72-1.22)
Non-binary gender	0.2 (2)	0 (0)	*Not calculated*
Prefer not to say	0.2 (2)	50 (1)	3.14 (0.19-52.39)
Age			
18-29	16 (166)	47 (78)	*Reference*
30-39	16 (163)	39 (64)	0.66 (0.42-1.05)
40-49	17 (176)	30 (53)	**0.47 (0.29-0.75)***
50-59	18 (185)	41 (76)	1.05 (0.66-1.66)
60-69	16.5 (168)	39 (66)	1.20 (0.74-1.96)
70+	15 (155)	44.5 (69)	1.60 (0.94-2.71)
Prefer not to say	0.1 (1)	100 (1)	*Not calculated*
Dependent Children			
None	66.5 (675)	35 (239)	*Reference*
Children <18 living with me	26 (262)	52 (136)	**2.59 (1.83-3.66)***
Children >18 living with me	5 (53)	36 (19)	1.05 (0.57-1.93)
Children not living with me	2 (24)	54 (13)	**2.55 (1.09-5.92)***
Pets			
Yes	53 (538)	45 (242)	*Reference*
No	47 (476)	35 (165)	**0.68 (0.52-0.89)***
Geographic Location			
Outside of London	88 (889)	40 (354)	*Reference*
London	12 (125)	42 (53)	1.07 (0.72-1.60)
Employment			
Not Employed	44.5 (452)	40 (179)	*Reference*
Employed	55 (562)	40.5 (228)	1 (0.72-1.39)
Education level			
Left school without qualifications	6 (59)	41 (24)	*Reference*
Secondary education	46 (466)	36 (167)	0.85 (0.48-1.51)
Higher education	48 (488)	44 (216)	1.24 (0.70-2.20)
Prefer not to say	0.1 (1)	0 (0)	*Not calculated*

*= Significant result

Table 5.7. *Association between predictor variables and intentional preparedness*

Variable and variable levels	% (N) of participants	% within variable level (N) classified as intentionally disaster prepared	Intentional preparedness adjusted odds ratio (95% CI)
General disaster risk perception			
No risk at all	12 (123)	36.5 (45)	*Reference*
A little risk	22 (224)	31 (69)	0.73 (0.45-1.18)
Moderate risk	25 (254)	38.5 (98)	1.07 (0.67-1.71)
Quite a high risk	26.5 (269)	42 (114)	1.12 (0.70-1.77)
Very high risk/quite probable	14 (144)	56 (81)	**2.01 (1.20-3.38)***
General disaster (with direct effect) risk perception			
No risk at all	18 (186)	31 (57)	*Reference*
A little risk	27 (272)	33 (91)	1.19 (0.78-1.80)
Moderate risk	31 (315)	42 (132)	**1.69 (1.13-2.54)***
Quite a high risk	18 (187)	48 (90)	**1.98 (1.26-3.12)***
Very high risk/quite probable	5 (54)	68.5 (37)	**4.33 (2.18-8.62)***
Nuclear attack risk perception			
No risk at all	26 (265)	36 (95)	*Reference*
A little risk	25 (258)	31 (79)	0.80 (0.55-1.17)
Moderate risk	22 (226)	41.5 (94)	1.39 (0.94-2.04)
Quite a high risk	18.5 (188)	48 (91)	**1.64 (1.09-2.46)***
Very high risk/quite probable	7.5 (77)	62 (48)	**2.46 (1.40-4.34)***
Nuclear attack risk perception (with direct effect)			
No risk at all	28.5 (289)	33.5 (97)	*Reference*
A little risk	25 (254)	33 (83)	0.92 (0.63-1.34)
Moderate risk	25 (251)	41 (102)	**1.47 (1.01-2.14)***
Quite a high risk	15 (150)	54 (81)	**2.34 (1.45-3.45)***
Very high risk/quite probable	7 (70)	63 (44)	**2.95 (1.66-5.24)***
General preparedness information received			
A great deal	2 (25)	92 (23)	*Reference*
Some information	11 (113)	75 (85)	0.26 (0.06-1.19)
A little information	10 (104)	56 (58)	**0.09 (0.02-0.44)***
No information	76 (772)	31 (241)	**0.03 (0.01-0.15)***
Nuclear preparedness information received			
A great deal	3 (35)	80 (28)	*Reference*
Some information	8 (86)	73 (63)	0.79 (0.29-2.12)
A little information	8 (78)	49 (38)	**0.26 (0.10-0.71)***
No information	80 (815)	34 (278)	**0.15 (0.06-0.38)***
Source of preparedness information			
Local authorities	17 (34)	79 (27)	2.15 (0.82-5.61)
Social media	25 (50)	76 (38)	1.41 (0.62-3.20)
Local news media	18 (36)	83 (30)	2.58 (0.94-7.13)
National news media	23 (45)	78 (35)	1.53 (0.64-3.67)
Friends or family	25 (49)	73 (36)	1.49 (0.67-3.29)
National government sources	23 (45)	69 (31)	1.33 (0.60-2.98)
UK nuclear agencies	9 (18)	72 (13)	1.21 (0.37-4)
International nuclear agencies	10.5 (21)	81 (17)	1.49 (0.44-5.04)
Emergency services	18 (36)	86 (31)	**3.82 (1.31-11.16)***
NHS	14 (28)	78.5 (22)	1.56 (0.56-4.36)
The military	13.5 (27)	81 (22)	2.80 (0.92-8.47)
Other	5.5 (11)	36 (4)	0.38 (0.09-1.67)
Cannot recall	11 (22)	36 (8)	0.43 (0.15-1.19)

How recently informed			
During the past year	19 (34)	70.5 (24)	*Reference*
1 – 5 years ago	45 (79)	76 (60)	1.14 (0.42-3.09)
6 – 15 years ago	19 (33)	64 (21)	0.75 (0.24-2.29)
More than 15 years ago	17.5 (31)	52 (16)	0.57 (0.16-2.05)
Perceived information sufficiency			
Yes	52 (92)	83 (76)	*Reference*
No	34 (61)	52 (32)	**0.24 (0.10-0.59)***
Don't know	13.5 (24)	54 (13)	**0.29 (0.09-0.89)***
Belief in protection from military			
Fully protected	12 (124)	61 (76)	*Reference*
Partially protected	43 (432)	44 (189)	**0.51 (0.33-0.79)***
Not protected	22 (225)	33 (75)	**0.33 (0.20-0.54)***
Don't know	23 (233)	29 (67)	**0.29 (0.18-0.47)***
Low perceived preparedness effort	3.65 (Mean total)	3.95 (Mean within variable)	**1.11 (1.04-1.20)***
High perceived preparedness effort	5.35 (Mean total)	5.51 (Mean within variable)	1.03 (0.97-1.10)
Sheltering Effectiveness	2.74 (Mean total)	3.20 (Mean within variable)	**1.22 (1.13-1.32)***

*= Significant result

Adjusted for demographic variables: gender, age, dependent children, ethnicity, employment and education.

5.3.3. Pre-incident communication preferences

5.3.3.1. Desire for pre-incident Communication

Table 5.8 shows the number of participants who expressed a desire to receive nuclear emergency risk communications. Two hundred and seventy-six (27%) respondents stated that they would not wish to receive information regarding preparedness and protective actions prior to a nuclear attack. The most commonly cited reason for this response was I don't believe I could be protected if the UK was attacked with a nuclear device whilst *other* responses often reflected this also.

Table 5.8. *Summary of responses relating to desire for pre-incident communications*

	% (Frequency)
Would you want to receive information regarding what actions you could take to prepare for a nuclear attack?	
Yes	73 (738)
No	27 (276)
Total	(1014)
When would be the best time for you to receive information regarding preparedness actions to take in a nuclear attack?	
Preferably any time before an attack is known	74 (548)
Only when an attack is known to be imminent	26 (190)
Total	(738)
Note: Respondents who selected 'No' in response to the question as to whether they would want to receive pre-incident communications were not shown this question	
Why would you not wish to receive preparedness information?	
I don't believe I could be protected if the UK was attacked	33 (116)
I don't believe the UK will be attacked with a nuclear device	26 (94)
I do not feel it would be possible to undertake actions advised	19 (67)
If an attack happened, the government would provide us with everything we needed	9 (33)
I would be too afraid	9 (32)
Other	4 (13)
Total	(276)
Note: Respondents who selected 'Yes' in response to question as to whether they would want to receive pre-incident communications were not shown this question	

Further responses marked *other* provided further responses to the question of why respondents would not wish to receive pre-incident information. For example, reflecting the statement: I do not feel it would be possible to undertake actions that would be advised.

More than 25% also selected I don't believe the UK will be attacked with a nuclear device in response to why they would not wish to receive pre-incident preparedness communications.

Binary logistic regression (Tables 5.9 and 5.10) found associations between being more likely to desire pre-incident communications and the following variables: being aged 40-59 years and; not believing preparedness information received to date to have been sufficient, or not knowing if it was sufficient. Respondents with a child over 18 years old living at home; those believing there to be little to very high risk of an unspecified disaster occurring during one's lifetime, or there being little to very high risk of a disaster occurring and it personally affecting themselves or loved ones; believing there to be a moderate to very high risk of a nuclear attack occurring on the UK during one's lifetime, or there being a moderate to very high risk of nuclear attack occurring on the UK and it personally affecting themselves or loved ones;

believing preparedness actions to be low in effort and; believing sheltering to be effective were less likely to desire pre-nuclear incident preparedness communications.

Table 5.9. *Association between personal variables and desire for pre-incident communications*

Variable and variable levels	% (N) of participants	% within variable level (N) who desire pre-incident communications	desire for pre-incident communications adjusted odds ratio (95% CI)
Gender			
Male	50 (503)	71 (359)	*Reference*
Female	50 (507)	74 (375)	0.99 (0.74-1.32)
Non-binary gender	0.2 (2)	100 (2)	*Not calculated*
Prefer not to say	0.2 (2)	100 (2)	*Not calculated*
Age			
18-29	16 (166)	80 (133)	*Reference*
30-39	16 (163)	78 (127)	1.16 (0.68-1.99)
40-49	17 (176)	69 (122)	**1.84 (1.10-3.06)***
50-59	18 (185)	64 (118)	**2.36 (1.41-3.94)***
60-69	16.5 (168)	72 (121)	1.51 (0.87-2.63)
70+	15 (155)	75 (116)	1.26 (0.69-2.31)
Prefer not to say	0.1 (1)	100 (1)	*Not calculated*
Dependent Children			
None	66.5 (675)	71 (478)	*Reference*
Children <18 living with me	26 (262)	76 (199)	0.80 (0.55-1.17)
Children >18 living with me	5 (53)	79 (42)	**0.49 (0.24-0.99)***
Children not living with me	2 (24)	79 (19)	0.56 (0.20-1.55)
Pets			
Yes	53 (538)	75 (405)	*Reference*
No	47 (476)	70 (333)	1.26 (0.94-1.69)
Geographic Location			
Outside of London	88 (889)	73 (650)	*Reference*
London	12 (125)	70 (88)	1.35 (0.74-1.74)
Employment			
Not Employed	44.5 (452)	74 (334)	*Reference*
Employed	55 (562)	72 (4042)	1.20 (0.84-1.7)
Education level			
Left school without qualifications	6 (596)	71 (42)	*Reference*
Secondary education	46 (4666)	72 (3352)	0.91 (0.49-1.68)
Higher education	48 (488)	74 (361)	0.84 (0.45-1.56)
Prefer not to say	0.1 (1)	0 (0)	*Not calculated*

*= Significant result

Table 5.10. *Association between predictor variables and desire for pre-incident communications*

Variable and variable levels	% (N) of participants	% within variable level (N) who desire for pre-incident communications	Desire for pre-incident communications adjusted odds ratio (95% CI)
General disaster risk perception			
No risk at all	12 (123)	55 (68)	*Reference*
A little risk	22 (224)	71 (160)	**0.49 (0.30-0.78)***
Moderate risk	25 (254)	68 (1728)	**0.61 (0.38-0.97)***
Quite a high risk	26.5 (269)	81 (218)	**0.30 (0.19-0.50)***
Very high risk/quite probable	14 (144)	83 (120)	**0.27 (0.15-0.49)***
General disaster (w/ direct effect) risk perception			
No risk at all	18 (186)	57.5 (107)	*Reference*
A little risk	27 (272)	71 (193)	**0.55 (0.37-0.83)***
Moderate risk	31 (315)	75.5 (238)	**0.45 (0.30-0.68)***
Quite a high risk	18 (187)	83 (155)	**0.30 (0.18-0.50)***
Very high risk/quite probable	5 (54)	83 (45)	**0.31 (0.14-0.70)***
Nuclear attack risk perception			
No risk at all	26 (265)	64 (169)	*Reference*
A little risk	25 (258)	66 (171)	0.92 (0.64-1.33)
Moderate risk	22 (226)	79 (179)	**0.49 (0.32-0.74)***
Quite a high risk	18.5 (188)	82 (154)	**0.44 (0.28-0.70)***
Very high risk/quite probable	7.5 (77)	84 (65)	**0.38 (0.19-0.77)***
Nuclear attack risk perception (w/ direct effect)			
No risk at all	28.5 (289)	63 (182)	*Reference*
A little risk	25 (254)	68.5 (174)	0.81 (0.56-1.18)
Moderate risk	25 (251)	77 (193)	**0.55 (0.37-0.82)***
Quite a high risk	15 (150)	83 (125)	**0.38 (0.23-0.64)***
Very high risk/quite probable	7 (70)	91 (64)	**0.18 (0.07-0.43)***
How recently informed			
During the past year	19 (34)	88 (30)	*Reference*
1 – 5 years ago	45 (79)	90 (71)	0.84 (0.21-3.37)
6 – 15 years ago	19 (33)	73 (24)	2.75 (0.67-11.31)
More than 15 years ago	17.5 (31)	90 (28)	0.70 (0.10-4.95)
Information sufficiency			
Yes	52 (92)	93 (86)	*Reference*
No	34 (61)	80 (49)	**6.01 (1.73-20.85)***
Don't know	13.5 (24)	75 (18)	**14.74 (2.90-75.05)***
Belief in protection from military			
Fully protected	12 (124)	76 (94)	*Reference*
Partially protected	43 (432)	78 (336)	0.77 (0.48-1.26)
Not protected	22 (225)	67 (150)	1.28 (0.76-2.14)
Don't know	23 (233)	68 (158)	1.25 (0.75-2.09)
Low perceived preparedness effort	3.65 (Mean total)	3.76 (Mean within variable)	**0.92 (0.77-1.83)***
High perceived preparedness effort	5.35 (Mean total)	5.37 (Mean within variable)	1.01 (0.74-1.73)
Sheltering Effectiveness	2.74 (Mean total)	2.88 (Mean within variable)	**0.88 (0.81-0.95)***

*= Significant result

Of those wishing to receive pre-incident communications, 74% reported that they would want this information preferably any time before an attack is known as opposed to only when an attack is known to be imminent (26%).

In response to the question of what two key pieces of information would respondents wish to see included in pre-incident communications, 30% selected information about how to prepare in advance for a nuclear emergency and 29% desired information about sheltering. Information about how to prepare for emergencies more generally was requested for inclusion by 21%. The least desired information was specific details of a nuclear accident and specific details of a nuclear attack. The most preferred methods of distribution were leaflet/letter delivered to one's home, as an online resource, and on television. The least desired was a council meeting and word of mouth. *Other* responses to method of distribution were few but included SMS and via e-mail, whilst further responses indicated methods by which the public might be informed in the event of an imminent attack such as using sirens. Full frequencies are reported in Appendix M.

5.3.3.2. Trust in information source

Table 5.11 shows the ranking of trust that participants gave to sources of information, respondents' anticipated likelihood of undertaking preparedness actions based on recommending source and anticipated likelihood of undertaking protective actions based on recommending source. National government was rated as most trusted, followed by UK nuclear agencies and international nuclear agencies. Friends/family and online forums/social media were lowest rated. UK nuclear agencies, emergency services and the military were considered to be the sources that participants would be most likely to adhere to instructions from if they were to recommend preparedness actions. Participants ranked emergency services, UK nuclear agencies and the military as the sources in response to which they would be most likely to adhere to protective instructions in the event of a nuclear attack.

Table 5.11. *Ranking of trust in source of preparedness information, anticipated likelihood of undertaking preparedness actions, based on recommending source and anticipated likelihood of undertaking protective actions, based on recommending source*

	Most trusted source of preparedness information			**Anticipated likelihood of undertaking preparedness actions, based on recommending source**			**Anticipated likelihood of undertaking protective actions, based on recommending source**		
Most to least: trusted / likely to take action if recommended	**source of information**	**mean trust ranking**	**standard deviation**	**source of information**	**mean likelihood score**	**standard deviation**	**source of information**	**mean likelihood score**	**standard deviation**
1	National Government	3.68	3.50	UK Nuclear agencies	6.06	2.59	Emergency Services	7.55	2.16
2	UK Nuclear agencies	4.19	2.71	Emergency Services	5.95	2.55	UK Nuclear agencies	7.44	2.27
3	International health protection or nuclear agencies	4.34	3.34	The Military	5.93	2.64	The Military	7.39	2.29
4	Emergency Services	5.23	2.37	International health protection or nuclear agencies	5.91	2.57	International health protection or nuclear agencies	7.36	2.26
5	Scientists	5.98	2.67	NHS staff or resources	5.62	2.47	NHS staff or resources	7.19	2.19
6	Local Authorities	6.22	3.19	National Government	5.53	2.55	National Government	7.18	2.35
7	NHS staff or resources	6.79	2.50	Scientists	5.44	2.48	Scientists	6.91	2.28
8	National news media	6.87	2.68	National news media	5.33	2.47	National news media	6.81	2.28
9	The Military	7.08	3	Local Authorities	5.19	2.43	Local Authorities	6.71	2.31
10	Local news media	8.53	2.44	Local news media	5.07	2.47	Local news media	6.58	2.25
11	Friends/Family	9.02	3.47	Friends/Family	4.59	2.56	Friends/Family	6.09	2.47
12	Online forums/Social media	10.07	2.30	Online forums/Social media	3.54	2.51	Online forums/Social media	4.63	2.66

5.4. Discussion

The UK was last exposed to nationwide communications aimed to educate the public as to how they can prepare for nuclear attack almost 40 years ago: The Home Office's Protect and Survive campaign (HMSO, 1980). Whilst Protect and Survive has been regarded with some disdain, both at the time of distribution (Thompson, 1980) and still today (Clay, 2018), almost 73% of respondents stated that they wish to receive pre-incident communications for nuclear attack preparedness; 74% of these people wish to receive this information preferably any time before an attack is known.

5.4.1. Preparedness

Using this survey, I aimed to identify the proportion of people possessing recommended items that might allow them to cope better with a nuclear disaster. The proportion who possess these materials specifically due to a concern about nuclear disasters or out of a concern for general emergencies was also assessed.

An average of three items considered necessary for nuclear disaster preparedness were found to be in the possession of respondents. Having a torch (and extra batteries) and a first aid kit were most commonly owned by a wide margin. However, a quarter of participants had a stored bag with cash and important documents (the least commonly possessed preparedness item) suggesting a reasonable level of preparedness overall. As was found in the previous survey conducted in Hawai'i, each preparedness measure was taken primarily for general emergency preparedness. Not only this, but rates of preparedness for each item were greater for a different type of emergency over nuclear preparedness. This suggests that the UK public have other disaster scenarios in mind when considering preparedness.

Amongst the many personal and predictor variables associated with intentional preparedness it is notable that high perceived likelihood of both unspecified and nuclear disasters were important with 74% believing there to be at least some risk of nuclear attack against the UK. Not only this, but associations extended to the moderate/high perceived risk of a nuclear or other disaster personally affecting themselves or loved ones. These associations were particularly strong. However, many respondents to this survey did not believe the UK to be protected from nuclear attack by the military, with only 12% believing the UK to be fully protected. This group are also less likely to intentionally prepare, an outcome that suggests some pessimism to exist: that whilst preparedness for some disasters is felt to be potentially effective, effective self-protection or effective military protection may not be felt to extend to catastrophic disasters.

Another notable outcome is that those who had received little or no general disaster or nuclear attack preparedness information, and those not believing, or not knowing if preparedness information received was sufficient, were less likely to intentionally prepare. Although it is impossible to determine causality in these associations, this is consistent with a beneficial effect of preparedness information and strengthens the argument for providing the public with such information, at least regarding general disaster preparedness. Of course, this could be an issue of recall. While approximately three-quarters reported not having received such information, Page and colleagues (2008) found that around half of their surveyed public could recall having received the Preparing for Emergencies booklet, though 40% had read it. Similarly, Rubin and colleagues (2006) found more than 60% of those surveyed to not recall receiving or received but not read the leaflet. This suggests that it is not enough to simply distribute preparedness information alone, but that encouraging preparedness behaviour requires a more concerted effort on the part of authorities.

That sheltering-related actions were perceived to be lower in effectiveness than evacuation (albeit to a location as far away as possible) is another argument for the provision of pre-incident information; in this case to educate on actions shown to be the safest to take when radiation is present. While it is undoubtedly true that being far from radiation is safer than sheltering close-by, pre-incident communications encourage the public not to place themselves in additional danger by attempting to flee. Perceptions of evacuation being the necessary response may be influenced by media reports of radiation disasters, such as the Fukushima plant disaster, which suggest evacuation to be necessary (e.g. Onishi and Fackler, 2011). In reality, evacuation can cause unnecessary exposure (e.g. Hashimoto et al., 2016). This is an important point on which to focus pre-incident communications, further evidenced by the fact that sheltering-related information was one of the two pieces of information most desired by survey respondents, representing a desire to increase understanding of appropriate response.

Emergency services were the only source of prior preparedness information found to be associated with intentional preparedness. This is interesting when we consider emergency services were rated highest for likelihood of adherence should they instruct the public to take preparedness or protective actions. Emergency services were not rated as the most highly trusted source however. This suggests that whilst the public consider other sources more likely to be accurate in their information, messages from emergency services carry a greater sense of urgency. It may also be that the public perceive emergency services to be more discerning in their public communication campaigns, whereas other sources, such as national government (though rated most trustworthy) are not. These factors (urgency and selectiveness in message subject) in combination may therefore be effective in influencing desired behaviours.

Absolute preparedness outcomes were comparable between the participants of this survey (3.02 out of 6 preparedness actions) and participants in the Hawai'i survey (3.71 out of 7). Mean intentional preparedness is similar also, though Hawai'i respondents, perhaps understandably considering geographical factors, appear slightly more prepared according to this metric (Hawai'i mean=2.93; UK mean=2.21). Overall, more personal and predictor variables were associated with intentional preparedness in UK respondents, however some of these factors were only recorded (risk perception, sheltering effectiveness) in the UK survey.

5.4.2. Pre-incident communication preferences

Associations between predictor variables and respondent's desire for pre-incident communications painted a less clear picture than for preparedness. This is evident in risk perception. One might expect that those expressing high perceived risk of a nuclear disaster occurring in the UK during their lifetime would be more likely to want preparedness information specific to nuclear attack. Instead however, the data suggests there to be less desire for preparedness information in those who believe there to be a risk of nuclear and of unspecified disasters occurring during their lifetime. What is clearer is that those who did not believe preparedness information they had previously received to be sufficient had a stronger desire for preparedness information now.

Preferences appeared to exist for pre-incident communications to be delivered during a time of no known threat with preferred distribution methods being a leaflet or letter directly to homes and online. This is consistent with previous studies of disaster preparedness, including radiation disasters (e.g. Pearce et al., 2013) and again demonstrates a desire to be prepared which will likely preserve life, if not in the unlikely event of a nuclear attack, but also in response to other types of disaster that might affect the UK. The spread of preferred methods in this survey suggests that a multi-method approach to distribution should be considered.

The most highly desired content of pre-incident communications was how to prepare for a nuclear attack and sheltering related information. The least frequently selected was information specific to nuclear accidents and information specific to a deliberate nuclear incident. Despite the inclusion of the word ‘specific’ in these choices, it may be that these were the least desired content as they are too vague or abstract in their description, the desire instead being for concrete and specific information. Also, only 21% selected information about general emergency preparedness; this is interesting since respondents’ report preparing for general emergencies, rather than specifically for nuclear attack.

Despite the positive appearance of these outcomes, there remains a minority who exhibited some of the beliefs identified in risk communication literature and in the previous survey: fear, fatalism and denial. We might also attribute such attitudes to the lack of desire for pre-incident communication in those believing there to be a high disaster risk, as detailed above. Whereas Hawai’i respondents to the question of why pre-incident communications are not desired were often able to refer to particular factors that they believed rendered preparedness or protective actions ineffective (such as the size of the island(s)), respondents in the present survey did not offer such specific detail.

5.4.3. Limitations

In the previous chapter (Hawai’i survey) I discussed several limitations that apply also to this study. These include the possibility to type 1 error occurring, recall bias and selection bias. Additional limitations, not previously discussed may also apply here and are described below.

Self-report responding increases the risk of social desirability bias. In this survey, and equally applicable to the Hawai’i survey, inflation of preparedness measures taken, may have occurred if respondents were actively trying to portray themselves as socially responsible. This may also extend to reporting a desire to receive pre-incident communications. This factor should be particularly noted since the high numbers expressing a wish to receive preparedness information runs in contradiction with focus group outcomes (Chapter 3), and what appears to be popular sentiment regarding previous nuclear preparedness campaigns (Protect and Survive). Many emergency preparedness campaigns have come into existence in the space between Protect and Survive and the present day which may provide an explanation for this discrepancy. Increasing exposure to such information campaigns (in schools, on public transport, in the workplace etc) and evidence gathering to optimise their positive impact (e.g. Hellier, 2014) may have made more recent public information campaigns more palatable, accessible, effective and necessary (Marshall et al., 2007) in public perception. This may therefore account for the perception of Protect and Survive as a ‘fantasy document’ (Preston, 2014) and not reflecting what is believed necessary in the modern day.

A median split was used to categorise intentional preparedness as being high or low. While this facilitated clear reporting of preparedness rates, this method is not without problems. Firstly, an assumption is made that all levels below the median are equal, as are all levels of preparedness above the split. An alternative method would have been to categorise the responses as three levels of preparedness (high, low and medium) and to remove the middle group. However, this would have reduced the sample size for analysis. Secondly, this method would have introduced a loss of power meaning that effects present in the data may have been missed.

Respondent demographics appeared broadly representative of the population in all areas for which data are available, apart from education, employment variables and having dependent children; respondents to this survey were more highly educated and less likely to be in full-time employment than the national average. Also, a greater number of childless adults responded to this survey than are nationally average. This should be considered when making inferences regarding population behavioural intentions.

The investigation of preparedness in this study may have benefitted from multivariate regression analysis. Using this model an understanding of interactions between predictor variables might have been explored, together with an assessment of the total variance explained by the variables studied. This latter aspect may have bene particularly pertinent in deciding whether the variables provided a good explanation for preparedness, or whether additional research is required. Stronger evidence could also have been gained in this study by moving forward to an 'A/B' experimental test of different forms of messaging developed using my model, and using a measure of intentions about preparedness as the outcome. Nonetheless, this study provides a sound basis for future studies of UK disaster preparedness. While the focus here was on nuclear attack preparedness, insights are gathered as to general disaster preparedness. Further, as is seen in the Hawai'i false alert, making preparedness materials available to the public does not necessarily equate to the public being motivated to act in the event of such as disaster. Further study in this area could therefore build on the knowledge gained here by developing insight into public understanding of the actions that might be required of them and how the undertaking of those actions could be facilitated in terms of infrastructure (for sheltering) and transport systems (for evacuation).

5.4.4. Implications

5.4.4.1. For policy

This survey allowed for separation between what is incidental preparedness (having items for non-preparedness reasons) from intentional preparedness. The finding that intentional preparedness occurs to a significantly greater extent suggests that emergency planners and communicators cannot rely on the UK having more than a few items that might prove necessary for prolonged sheltering without making a concerted effort to collect them.

It appears that much time has passed since nuclear preparedness information was last received by many. This is evidenced by the reporting of preparedness information received in open text response, and the outcome that 20% had received such information more than 15 years ago. This survey demonstrates a desire for pre-incident information, particularly preparedness and sheltering information, which is seen as low in effort.

When informing the public of sheltering instructions, information should be included as to why this is an effective method and what sheltering involves (including shutting windows, not approaching windows and placing oneself in a location central within the building). The dangers of evacuation should also be included. Whilst previous phases of this study (systematic review and focus groups) have shown there will still be people who ignore sheltering instructions, for various reasons such as picking up children/being with family, or simply to get as far away as possible, there is likely to be an opinion in the public that evacuation is the only effective safety measure to take. Many may attempt evacuation contrary to advice, risking exposure to radiation and nuclear blast associated hazards, as was witnessed in Japan following the Fukushima disaster (e.g. Hashimoto et al., 2016).

It is notable that of those not wishing to receive pre-incident information, less than 10% selected the response option: if an attack happened, the government would provide us with everything we needed. Coupled with the low effort ratings of preparedness actions and a general desire for pre-incident information amongst respondents, this suggests that the public do not believe the government will provide supplies in the event of a nuclear disaster, but also don’t view it as a hardship to accumulate items themselves.

Pre-incident communications should also be distributed via various channels to maximise reach. In Hawai’i this was attempted online (HI-EMA), town hall meetings (Teague, 2017) and by publicly testing cold war emergency sirens (Broder van Dyke, 2017), but with limited success. For example, town hall meetings were rated as relatively high in effort in Hawai’i (Chapter 4) and are arguably less commonplace in the UK, being selected as the preferred method of information distribution by the fewest number of present survey respondents (who would presumably also rate this as high in effort) below word of mouth. In fact, watching online preparedness videos were rated as higher in effort than storing cash and important documents, putting together a first aid kit, obtaining a battery powered radio and spare batteries and obtaining a torch (and extra batteries) in the present study suggesting this method to not be simple or accessible for all citizens. Again, not all the UK public will accept, or be able to access pre-incident communications for nuclear attack preparedness no matter the method of distribution, but by focussing attention on evidenced preferences (leaflet/letter, online, television, radio) the likelihood of reception will increase.

The importance of trust in the source of communications represents perhaps the most significant discrepancy between systematic review (Chapter 2) and focus group (Chapter 3) outcomes. In the review, engagement with communications and subsequent adherence with instructions was found to be enhanced in those who trusted the credibility of the message source (Latré et al., 2017; Murakami, 2016; Perko et al., 2013; Rogers et al., 2013). In the focus groups there appeared to be an inherent distrust in current and previous protective advice. Importantly, trust in message source was found to matter little with regards to nuclear threat. In fact, trust in source was considered unimportant if the perceived effectiveness of recommended actions was low or if the effort involved in carrying out actions outweighed the perceived potential risk of harm. Specifically, trust was considered to not influence adherence with protective actions if those actions are considered unreasonable or not evidence-based. One way in which trust is fostered in sources however, is by drawing upon an evidence-base to make public health recommendations.

In the present survey, participants rated national government to be the most trusted source. However, rankings differed between trusted sources and those sources who would inspire the greatest level of adherence, with UK nuclear agencies, emergency services and the military being the top three rated. Interestingly, very little previous preparedness information was reported to have come from UK nuclear agencies (a source also found to rate highly for trust), a finding that seems objectively accurate: at the time of writing, the websites of the UK Atomic Energy Authority; The Office for Nuclear Regulation and The Atomic Weapons Establishment (the three main UK agencies in this area) contain little public safety advice.

5.4.4.2. For this PhD

To re-introduce the epistemological stance of using differing methodological approaches to gathering data in this PhD, there were benefits of conducting a survey at this phase of the research. It was evident from the focus groups that there is interest in preparedness information in some, but that preparedness rates were anecdotally low. This survey allowed for expanding on the participant sample and for quantifying rates of preparedness and desire for nuclear risk communication. It also facilitates testing of factors raised as important in focus groups, such as who is most trusted to communicate with the public amongst other central factors. Amongst key factors from the focus groups that have implications for this PhD and were tested in this survey were that information received does not influence subsequent adherence if the perceived effort involved in undertaking protective actions is judged to outweigh the protection those actions would offer. This represents a cost-benefit analysis (e.g. Ahmed And Daw, 1980; Carr et al., 2018) to the individual. In this case cost could presumably be financial or time-consumption, whilst benefit is the perceived life-preserving effectiveness of the measure. In this study, the gathering of preparedness items were all ranked as relatively low in effort and actions which may be required in the event of a nuclear disaster (sheltering and evacuation) were relatively high: although only the top three most highly rated for effort (*be prepared to leave your home to a place of shelter outside of your town or village; be prepared to leave your home to a place of shelter within your town or village* and; *be prepared to shelter (e.g. at home) for up to 2 weeks*) scored above 5 out of 10 for effort. One would presume however, that in the event of a nuclear attack, perception of effort would reduce in survivors.

In scores of response-action effectiveness, it is also interesting to see that the three sheltering-associated actions are perceived to be the least effective. In fact, sheltering is ranked lower in effectiveness than taking Stable Iodine. Previous phases of this study have shown that Stable Iodine, and its purpose, are not widely known, particularly in areas away from nuclear power plants. Even in those areas, storing Stable Iodine is not widely undertaken.

Overall, effectiveness ratings are low; only the top two actions (*getting underground* and *leaving your home for a destination as far away as possible*) were considered more than 50% effective on average. Leaving home being the most highly rated for effort, suggesting once more that the public undertake a cost-benefit analysis when preparing; with factors such as fatalism and risk perception influencing whether benefits of taking action outweighs the costs. There is little to separate the strength of association between perceived effort and *intentional* preparedness ($B=1.11$, $p>0.003$) from perceived effectiveness of sheltering and *intentional* preparedness ($B=1.22$, $p>0.001$).

A positive conclusion that might be drawn from effort and effectiveness ratings comes from considering the perception of sheltering. Whilst sheltering is rated as relatively low in effectiveness, it is also rated reasonably low in effort (around 50%). The perception of an action's effectiveness appears to be one that can be influenced by using effective public information. This is perhaps the most central tenet that this PhD aims to address. Sheltering ability is reliant on preparedness, specifically the acquisition of the items rated as low in effort in this survey. In other words, sheltering is only as effortful as the most effortful preparedness actions (i.e. storing medication, food and water).

In summary, respondents to this survey were intentionally prepared (for general disasters) if:

- protective actions (i.e. sheltering) are perceived to be effective;
- preparedness actions are perceived to be low in effort;
- they have received ample and sufficient preparedness information, and;
- the risk was perceived to be high enough

However, further pre-incident communications are desired if:

- disaster risk perception is low; and
- previous information received is considered insufficient.

Furthermore, information was not desired if individuals had already undertaken low effort preparedness actions or they believe sheltering to be an effective protection from radiation.

5.5. Conclusion

The outcomes of this survey suggest a desire in the UK public to be prepared for the unlikely event of a nuclear attack. Preparedness and knowledge of protective actions will likely preserve life not only in a nuclear attack, but also in other disasters. Few respondents reported having received preparedness information, but those who had were more likely to have prepared intentionally. Perhaps centrally, those who have received preparedness information had undertaken low effort actions and believed in the effectiveness of sheltering. This suggests that the problem is not the current messages themselves, but the poor dissemination of those messages. Preferences for how preparedness information should be delivered, by whom it should be distributed, and its content have important implications for policymakers and emergency planners in their design of life-preserving public preparedness education.

Chapter 6: Discussion and Recommendations

6.1. Introduction

6.1.1. Summary of the problem

In this thesis the challenges that exist in educating the public as to effective preparedness for, and response to, a nuclear catastrophe have been outlined. This problem has been laid out in Chapter 1, but to re-summarise the problem that this thesis aims to address, these include beliefs about CBRN lethality (Sheppard et al., 2006), unfamiliarity (Covello, 2011) and unpredictability (Smith, 2010) which can elicit intense emotional responses such as anxiety (Becker, 2004) and attitudes such as fatalism (Taylor et al., 2011). The result of these phenomena is that individuals can avoid or dismiss risk communications (Rogers et al., 2013). However, further complexities exist: at what stage in the timeline of the event do we target our communications? Do we wait until a known risk exists or communicate during peacetime at risk of being ignored by the public? The issue of trust frequently arises in public health communications, but how do we know who is trusted to communicate? And how can trust be fostered? In addition to the question of who communicates, does the 'how' make a difference to acceptance and influence on behaviour towards increased preparedness? These are important questions as production and distribution of effective preparedness communications can facilitate engagement and may improve disaster preparedness, which in turn may predict adaptive, protective behaviour in the event of a radiation emergency (Taylor et al., 2011). So, how can we most effectively communicate with the public about nuclear disaster preparedness?

6.1.2. What did this research achieve?

Evidence-based development of effective nuclear risk communications should maximise the likelihood of increased preparedness for a nuclear disaster. This research intended to add to our understanding of attitudes and behaviour in preparation for and response to an emergency involving nuclear materials. The aims of this project were to:

1. Identify predictors of behaviour in preparation for, and in the immediate aftermath of an incident involving release of nuclear radiation, and;
2. Identify how best to communicate pre-incident information to the public.

These aims were addressed over three phases. First, a systematic review identified what is already known about preparedness and reported public information needs for a radiation disaster, as well as adherence to recommended protective actions. Second, a set of focus groups identified: public perceptions of nuclear attack and nuclear plant radiation releases; reported information needs before and during a nuclear incident; ways to provide this information, and; facilitators or barriers to engagement with pre-incident communications. Finally, two online surveys (with members of the public in Hawai'i and the UK) quantified actual and expected behaviours during an incident believed to involve a nuclear attack as well as preparedness and information preferences, and tested whether possible predictors of behaviour identified in the previous phases were associated with perceptions and behaviour. Using these methods, the present research findings have added to what is known in the context of nuclear preparedness communications in the UK and corroborated previous findings, particularly in the context of CBRN and public health communications.

6.1.3. Unique contribution to knowledge

This research lays the groundwork for the development of effective pre-nuclear attack communications to be distributed to the UK public. No other study has explored information preferences for catastrophic nuclear attack preparedness in the UK. Indeed, evidence for guidance development anywhere is scarce. Often, this research is designed to explore reported information needs when a threat is imminent and is not designed to inform the public of nuclear attack preparedness at a time of no known threat.

The last UK information campaign of this nature (Protect and Survive) was developed over forty years ago. Whilst much of the recommended actions in Protect and Survive hold true today (Dodson, 2014), its high-profile faults meant it received resistance upon distribution. Contemporary evidence for public information needs can aid in remedying previous mistakes.

This research has produced novel findings about how we should communicate with the public about nuclear preparedness, though evidence exists that compliments or challenges some of these findings. For example, previous research suggests trust in the communicating source to be vital in whether recommended actions are adhered to (e.g. Lofstedt, 2003; Wray et al., 2006). My research does not contradict this, but it was apparent in these studies that trust is invalidated should recommended actions be considered unreasonable, unachievable or inefficacious. This is perhaps a circular issue since trust is fostered in part by making instructions reasonable, achievable and efficacious, however, a communicating source cannot assume what is reasonable to one is reasonable to all. As is shown, this assumption may result in reduced adherence.

A further unique finding is the preference for nuclear risk communication to be embedded in our institutions, or to be 'drip-fed' into the public; this challenges the importance of the correct method being used, and arguably even the most appropriate source. An obvious counter-argument exists regarding the introduction of 'nuclear disaster drills' into schools and the workplace, however. That is, we perform drills and practices, such as fire and first aid, because we perceive the risk of these events to be greater than that of nuclear attack.

This research was also the first test of pre-incident communication preferences in a population who had experienced existential nuclear threat. Undertaking of a near equivalent survey with a population who have not faced this experience allowed for comparison between self-reported information preferences. As previously discussed, this has provided further unique findings: that around three-quarters of those surveyed desire pre-nuclear incident communications whether or not they had recently experienced nuclear attack threat, but also that those believing the risk of disaster to be high are less likely to desire pre-incident communications.

6.1.4. Strengths and limitations of research

Strengths

In the systematic review, many of the conclusions, particularly related to attack scenarios, relied on outcomes of studies that explored hypothetical scenarios. One clear strength of this PhD was that adherence to an actual instruction to shelter in a population facing imminent attack could be quantified in the Hawai'i survey. In that survey more than half of the respondents believed themselves to be at risk of a real and imminent catastrophic nuclear attack. Other studies of radiation emergency response have drawn on actions taken in accidental nuclear radiation leaks, the features of which differ from the situation experienced by Hawai'i. Many of the Hawai'i survey outcomes aligned with the outcomes of the other survey, conducted with a UK population. This suggests that there remains value in using hypothetical situations to inform research of this type.

A further strength of this research is its scope. For reasons outlined above, the systematic review encompassed nuclear and radiological, deliberate and accidental radiation disaster scenarios and reported information needs at pre- and during incident periods. This allowed for exploration of key variations in reported information needs. The scope could then be refined to that of nuclear attack communications as research phases were progressed through. Recommendations are focussed on attack-specific outcomes where possible, but have drawn on evidence from studies of radiological device detonation and accidental radiation leaks where appropriate. I believe this to have been an appropriate method for reporting outcomes and that where I have done, recommendations for nuclear attack risk communication are richer for their inclusion.

Related to the scope of the project, another strength is the step process that was used in which each study built on the last. The paucity of data specific to nuclear catastrophe means that building upon known aspects in fields related to health and disaster communications has enabled the provision of a sound empirical base for this work and opened up avenues for future research (which are further discussed below). The approach taken to answering this question has been loosely structured on this process in that sometimes this meant that dead ends were not followed up, but the use of multiple methods in this process was beneficial in several regards. First by conducting a systematic review that covered a wide scope it enabled a broad overview of all important aspects of this topic which could be drawn together for exploration in the first phase of original data collection. Next, using qualitative methods allowed for the development of novel survey items that might otherwise have been missed (such as informing the list of sources to be rated for trust). The next, quantitative, phase allowed for triangulation of findings. This integration is not always easy however, for example there was a clear discrepancy as to whether pre-incident information was desired. Nonetheless where similar findings can be found in the focus groups, UK survey and Hawai'i survey, it provides greater confidence in their veracity.

Limitations

Study limitations have been discussed within each chapter, however a few more general limitations should also be considered.

While a strength of this PhD related to its scope, covering nuclear and radiological dispersion devices, it was evident in the existing literature that the terms nuclear and radiological are a) often used interchangeably by experts (e.g. Bakhshi et al., 2014; FEMA, 2016) and b) often conflated in the minds of the public. Both were included in the review which also included studies of deliberate nuclear detonation and nuclear power plant accidents. Of course, there are no data on actual response to deliberate nuclear attack, whereas nuclear plant leak response data provides accounts of actual behaviour. As previously stated, the false alert incident in Hawai'i was the first credible attack warning to be researched in terms of actual public response. Studies from preparedness and immediate response phases were also included in the review. While this was useful to gather data from both points in time, there were also studies included wherein no distinction was made between risk communication (given during a period of no threat) and emergency risk communication (given immediately following the emergency occurring). Also, other than those exploring the use of stable iodine, studies of nuclear plant accident response wholly related to emergency risk communications and public response behaviour, rather than preparedness. To summarise, the limitations relating to scope are a lack of data in the literature review relating to preparedness, and a lack of comparative data for adherence in actual nuclear attack to which the Hawai'i survey outcomes could be measured.

For pragmatic reasons only studies written in English were included in the systematic review. Much research was conducted following the Fukushima nuclear plant disaster, some of which was published only in Japanese. Similar issues may apply to the Chernobyl disaster and in countries experiencing or having been threatened by nuclear attack (for example, Japan or Korea). It is possible therefore that some studies of relevance were not included. Following this, data was collected using focus groups and surveys only available to English-speakers. Again, cultural differences may limit the generalisability of these data. There are also likely to be cultural differences that influenced Hawai'i survey outcomes. For example, some respondents stated in open text that they considered firearms as preparedness items – something unlikely to apply in other cultures where firearm ownership is limited. Previous studies have been in geographic regions where evacuation may be more widely considered, or recommended in some nuclear power plant emergencies, or with populations living only in brick buildings. Many respondents commented that evacuation is not an option on Hawai'i's islands or that sheltering was not an option in wooden houses. Whilst a strength of this research is in the cross-cultural data collection, a limitation is the ability to extrapolate across studies.

Changes over time should also be considered when interpreting these outcomes. For example, studies were included in the systematic review that followed the Three Mile Island disaster which occurred fifty years before the time of writing. Concepts and knowledge of preparedness have likely changed since then just as historical context has changed with emerging nuclear super-powers, and formed and broken nuclear treaties, all reflected in the ticking minute hand of the Doomsday Clock. The generation who originally received Protect and Survive no longer have young children. Technology, and the potency of nuclear weapons have changed. In fact, in mid-2018 (during the period of this research), FEMA revised their nuclear disaster planning guidance to account for 100KT to 1000KT detonations, up from their original 10KT (The National Academies of Science, Workshop, August 2018). This represents a change in focus from smaller devices possibly deployed by terrorists to larger thermonuclear attacks by state actors. Whilst detonation models of damage and potential fallout have been updated by the Lawrence Livermore National Laboratory to reflect this amendment, it is notable that these models show that an explosive yield ten times larger than those previously modelled do not result in ten times the damage. Guidance, such as to remain in a (preferably concrete) shelter until advised otherwise still holds as the most effective protection from associated aspects of nuclear attack such as radiation sickness (Vergano, 2018). Other than perhaps influencing perceived risk, this change in US government planning likely matters little in terms of the aims of this research.

6.2. Key findings and implications

Presented here are the key findings that have arisen from this work. For clarity it has been indicated which of the recommendations associated with these findings are direct outcomes of this research, and which come from the past literature. An opinion as to the strength of the evidence-base for each recommendation is also given using the following terminology: strong (e.g. confirmed by two good quality studies), medium (e.g. one good quality study, or several lower quality studies) or weak (e.g. inconsistent evidence or only in one low quality study).

6.2.1. Disaster preparedness is mixed

From this thesis:

Preparedness in the survey respondents appeared to be higher than what was suggested by focus group participants. Both Hawai'ian and UK participants were found to have obtained around half of recommended items intentionally for general disaster preparedness. It was not clear whether item gathering was the direct result of receiving preparedness instructions or if preparedness was based on what the public perceived to be necessary for disaster preparedness independent of guidance. Also, the method of using a median split to categorise preparedness as high or low in the analysis of these surveys should be considered as this has the potential of misleading interpretation; using an absolute criterion for preparedness may have been preferable, although to my knowledge no such criterion currently exists.

In the UK survey having received little or no general disaster preparedness information, or little to no nuclear attack specific preparedness information and not believing, or not knowing if preparedness information received was sufficient was associated with low preparedness. By contrast, higher levels of preparedness were associated with high nuclear attack risk perception. But importantly, in the Hawai'i survey no association was found between being prepared for a disaster and subsequent adherence to the recommendation to shelter. This suggests that it is not enough for communicators to simply tell the public how to prepare – people must be informed as to how to respond in the event of a nuclear disaster occurring.

From previous literature:

Outcomes of the review suggested strong evidence for generally low disaster preparedness in the public. Barriers to preparedness included believing there to be no time to evacuate in an emergency (Malešič et al., 2015) and unwillingness to follow instructions (Guterbock et al., 2010; Williams et al., 2005). There was also little alignment with factors associated with preparedness. In the Chapter 2 review, two studies of terrorism found preparedness to be associated with: being older, a resident of rural areas, having higher education (Lemyre et al., 2007), perceived probability of an incident, coping efficacy, perceived front-line preparedness and worry (Lee and Lemyre, 2009). Furthermore, we cannot definitely say that disaster preparedness alone results in survival without the need for outside assistance (Perman et al., 2011). Heagele (2016) found a lack of evidence that disaster preparedness results in self-sufficiency or resilience when required. In fact, contrary to current belief, it might be that taking preparedness measures is counter-productive: in a survey of New York residents following superstorm Sandy, an association was found between preparedness (amassing recommended items and making evacuation plans) and perceived non-recovery whilst having stored medication was associated with requiring mental health and medical services in the days following (Clay et al., 2019).

6.2.1.1. But what is 'prepared' in this context?

Ultimately, with this mixed picture of preparedness, the question should be asked as to what level of preparedness should we strive for? And how might we define 'being prepared' for a disaster of this magnitude? Recognised preparedness guidance (FEMA, 2018; HI-EMA, 2017; HMSO, 1980) was drawn from in formulating lists of preparedness items for the surveys undertaken in the PhD; however, a lack of consistency exists in recommended CBRN preparedness. Other documents (e.g. American Red Cross, 2006; CDC, 2005; DHS, 2006) suggest more items are necessary. Preparedness literature often indicates that the public are not disaster prepared: survey respondents had around half of the suggested items, though if longer lists were used, they may appear less prepared. For example, recent campaigns such as the Federal Emergency Management Agency's 'Ready' campaign states that general disaster preparedness involves having "thought about and planned for the types of disasters for which (individuals and groups) are at most risk, have developed a family communication and evacuation plan in the event of a disaster, and have assembled a complete disaster supply kit"

(DHS, 2018). Whether family communication plans had been formulated was not directly examined in this research, however, focus groups said they would look to reunite with their families rather than follow sheltering advice which suggests that few had made a plan that was consistent with published guidance. Redlener and colleagues (2004) suggest a lack of both logistical and emotional preparedness in the public. In a 2017 National Household survey of preparedness conducted across the US, FEMA found around half of respondents had taken three of six preparedness actions that included taking part in a drill, talking with others about preparedness and developing a household plan. However, whilst almost all had amassed supplies for three days without electricity, less than one in five had attended a meeting or undertaken formal emergency preparedness training (FEMA, 2017). If we use these definitions, then preparedness is more than simply amassing supplies. This is also important as Heagele (2016) found that a lack of consensus regarding recommended disaster preparedness is likely to result in individuals compiling suboptimal disaster supply kits. What's more, Florig and Fischhoff (2007) have shown the financial cost of preparedness is greater with longer lists and therefore is likely to be prohibitive for many. However, in the event of a nuclear catastrophe it is doubtful as to how effective owning a torch would be. On the other hand, torch ownership, in addition to the acquiring and storing of other items of limited use in such an event, may be a marker of a wider acceptance of the need to be disaster prepared that for many is likely to extend to awareness of more effective countermeasures such as sheltering. Prioritising preparedness actions, rather than insisting that all must be completed, may be beneficial. In this regard, it is positive that hope can be gained by the fact that the key protective action for nuclear incidents, sheltering, was considered low in effort by many of the survey respondents. This is an area that can be addressed in pre-incident communications and doing so could result in increased public preparedness. It is also notable that preparedness was rarely for nuclear attack preparedness, but instead for general preparedness. The consistency between items collected for general preparedness in the present research and those recommended for nuclear preparedness in previous literature suggests some evidence that communicating about general disaster preparedness is preferable and perhaps more efficacious than communicating specifically about nuclear preparedness. This positive indication towards a general preparedness among the public can be traced to the concept of agility that was introduced in Chapter 1. Preparedness for multiple events heightens ability to call on protective actions that are appropriate to the set of circumstances and suggests a recognition that a serious threat exists, even if not acknowledged explicitly. Pre-incident risk communication can be used not only to educate, but to support the public to enhance flexibility and resilience towards a threat by recognising effectiveness of actions that can protect against a nuclear attack and to respond quickly if required. This latter point speaks to the issue of anticipation of the threat which may go some way towards heightening the emotional readiness as addressed by Redlener and colleagues. Along with agility this anticipation is arguably as important or perhaps more so than amassing listed supplies.

6.2.2. Those who perceive that a nuclear disaster is likely to occur are more prepared (but do not necessarily want to be told how to prepare)

From this thesis:

In the UK survey, there was strong evidence that prepared respondents were those generally believing there to be a moderate to very high risk of an unspecified disaster or nuclear attack occurring against the UK and it personally affecting themselves or their loved ones. High risk perception was also associated with acceptance of pre-incident communications: those same people were generally less likely to desire pre-nuclear incident communications. This was explored in focus groups where protective instruction was felt to be required only in the event of nuclear attack risk being known to be high (i.e. when an attack is imminent). This represents a discrepancy in the results that may require further exploration and is discussed further in the next section.

Focus group participants also felt that the likelihood of an attack was low but that their perception of likelihood might rise should preparedness communications be distributed. Some focus groups suggested that knowing the current national threat level would influence their response to preparedness instructions; however, intensifying of threat warnings, or simply perceiving there to be a general increase in terrorism, without personal consequence was felt to desensitise them to the threat, reducing their likelihood of making preparedness-related lifestyle changes. Such an effect of public perception has been shown by Stevens et al (2011) who suggested that community adaptation (‘habituation’) occurs quickly in response to terror events. This leads to reduced concern and perception of likelihood.

This represents a critical concern for risk communicators: We communicate risk and recommend preparedness measures to reduce the likelihood of harm to the public if that event occurs. However, if the public remain unaffected, their desire for risk communications is reduced. This is in contradiction to the belief that risk information should be normalised in the public to aid recall (see section 6.2.7 below). Risk communicators may need to be careful to avoid implying that raised risk is the sole motivating factor in distributing preparedness materials.

6.2.3. Despite these barriers, people want nuclear preparedness information

From this thesis:

Although attitudes varied as to whether pre-incident communications for nuclear disaster preparedness were wanted or required in focus groups, a strong desire for nuclear attack preparedness communications was evident in survey respondents overall (83.5% in Hawai'i; 73% in the UK). In fact, a large majority of these groups expressed a preference to receive communications during a period of 'no known threat' as opposed to, 'when a threat was imminent'. However, this was in direct contradiction of views expressed by the focus group participants who preferred to receive information only when a threat was imminent. While it is tempting to suggest that recent experiences in Hawai'i boosted their desire for information, the high proportion of participants requesting information in the UK survey suggests that this is not the whole story. The question exists then: does high perceived risk of a nuclear attack increase or decrease desire for pre-incident preparedness communications? An explanation offered by the present data is the preference for 'drip feeding' information into the public. In short, this is the desire for preparedness information to be embedded in established institutions, rather than coming in the form of a one-off information campaign. In this instance, survey respondents who had not received preparedness information were less likely to be prepared. The lack of nuclear preparedness information in the public during living memory for many suggests that preparedness information has come from alternative sources, a sort of 'drip feeding' in itself. Survey respondents did not dismiss the idea of preparedness information, in fact many expressed a desire for information during a time of no known threat. In this case, two suggestions can be made: firstly, that drip feeding preparedness information that is general, rather than specific to the type (nuclear) of disaster can promote preparedness when it is less explicit than a one-off campaign, and secondly that the timeline of the event should be considered carefully in distributing preparedness information, i.e. drip feeding information during peacetime can be effective, there may be little desire for slower time preparedness information should the risk be known to have increased, however if an attack is known to be imminent then information as to immediate actions is desired.

An alternative possibility is that the difference reflects the different methods of data collection used. While survey respondents may have considered the question of pre-incident information in a purely rational manner and concluded that it would be sensible to have information regarding risk and preparedness, the setting of a focus group may promote a different response, with participants who spend longer reflecting and discussing the issue coming to understand that they will be likely to pay attention to risk information in the absence of an immediate threat.

Reasons for believing pre-incident communications were unnecessary included: fatalism, a desire for 'blissful' ignorance, uncertainty as to what exactly would happen in a nuclear attack, perceived failure of past public information campaigns, detachment from the city of residence (or not feeling oneself to be a permanent resident of the place in question) and lack of interest. Some also felt that preparedness is a barrier to exercising common sense in the event. The most common reason selected for not wishing to receive nuclear risk communication in both surveys was, 'I don't believe I could be protected if Hawai'i/the UK was attacked'. Respondents who did not believe preparedness information received to date was sufficient, or did not know if it was sufficient expressed a desire for nuclear pre-incident communications. This provides evidence to support the recommendation that nuclear risk communications should be clear, transparent and consistent.

6.2.4. The public want to know about preparedness, countermeasures and radiation in the event of an incident

From this thesis:

In both surveys, preferred pre-incident content largely concerned preparedness (e.g. what to include in an emergency kit), sheltering (e.g. how and where), radiation effects (e.g. how to recognise radiation poisoning) and stable iodine (e.g. why it helps). Content to be distributed in the event of a nuclear attack concerned evacuation (e.g. planned procedures), family-centric needs (e.g. how to protect loved ones), detonation effects (e.g. the range of damage) and actions of authorities.

Focus group outcomes were that rather than pre-incident content containing specific advice which may not be suitable for all, a range of actions for varying radiation-disaster situations should be included. This could include worst and best-case scenarios designed to reassure people that their actions are appropriate. Explanation as to why actions are advised was also requested, to manage fear and expectations. In fact, groups felt that their ability to adhere to instructions was reliant on their perceived ability to carry out the actions 'properly', so these needed to include adequate information (such as how long to shelter) and they would be seeking reassurance that their personal circumstances would be accounted for in the guidance. Low self-efficacy was linked to fatalism by the focus groups and reduced engagement with communications. This was echoed in the UK survey where not feeling that it was possible to undertake countermeasures was a reason for not wishing to receive pre-incident communications. One study in the literature review also found large numbers willing to shelter but perceiving themselves lacking in resources to do so (Williams et al., 2005). These constraints evident in both the present research and the previous literature strongly suggest that the public may not shelter in the immediate aftermath of a nuclear attack when radiation levels are highest, in favour of seeking out alternative locations of safety.

According to the focus groups participants, information should be brief, and include visuals, bullet points, logos or catchphrases to capture attention and encourage engagement. A desire was expressed for two-to-three simple actions to take in the event, particularly if relevant to different scenarios.

From previous literature:

The original finding of a desire expressed for two-to-three simple actions that are relevant would correspond with what has been referred to as 'survival processing': recall of details perceived to be most central to survival (Naire and Panderirada, 2011), and aligns with Edworthy and colleagues' (2015) finding that where emergency risk information is comprehensive, elements that can be inferred from elsewhere, such as other risk communication, are best recalled. This is also consistent with strong evidence from a randomised control trial included in the systematic review in which preference was expressed for a nuclear safety leaflet, which was felt to be easier to understand, and which offered a pin-up summary with pictures (Hellier et al., 2014).

Based on the outcomes of this research several specific recommendations as to content can be made:

- There is strong evidence to show that pre-incident communications should provide information relating to: preparedness; sheltering; radiation effects and, if appropriate, stable iodine. Preparedness information should include: emergency supply kit contents and amounts to store; how to prepare for a nuclear attack and, how to prepare for any emergency. Sheltering information should include a short list of the following actions judged to be most important for increasing the chance of survival: how and where to shelter; what to do if lacking an appropriate shelter (or if driving); how to know whether to shelter at home or elsewhere; how to ensure effectiveness of home shelters (such as creating a functional toilet); how long to shelter and; why sheltering is recommended. Radiation information should include types of radiation and how to recognise radiation poisoning; what removes radiation; how to avoid exposure; how long the radiation would take to clear (including how long to stay sheltering) and; the longer-term effects of fallout. Detonation-related content should also be included, such as the potential range of damage. Stable iodine information should include when to use it, why it helps and, side-effects.

- To facilitate increased engagement, evidence is strong that pre-incident communications should detail actions that authorities would take in a disaster, including how food would be supplied to affected people.
- Pre-incident communications should also contain a range of actions for varying radiation-disaster situations. Some (medium-quality) evidence from this research suggests that this might include worst and best-case scenarios and personal accounts of radiation-exposure survivors and an explanation as to why evacuation is advised if this is an anticipated order. This also includes what to take if evacuating and planned evacuation procedures (e.g. modes of transport).
- Further, pre-incident communications should contain two-to-three simple actions (i.e. the most vital instructions relating to sheltering, above) to take in the event, particularly if relevant to different disaster scenarios. There is medium evidence that communications should also be brief, include visuals, bullet points, logos or catchphrases.
- To facilitate increased adherence with protective instructions in the event of a nuclear attack, there is medium evidence to suggest that messages should provide of a range of actions tailored to different scenarios.
- To facilitate increased adherence with protective instructions in the event of a nuclear attack, it is strongly recommended that messages should provide adequate information (such as how long to shelter) to enable the public to fully and effectively undertake actions.

A further recommendation that entails findings from previous literature, is:

- To facilitate increased preparedness, pre-incident communications should be clear in their layout and recommended actions; this includes provision of literacy aided materials for those with language deficits.

6.2.5. Fatalism is a barrier to engagement with risk communication

From this thesis:

Fatalistic attitudes were a common reason for not wishing to receive pre-incident communications in both surveys. In Hawai'i, fatalism was also amongst reasons cited for taking no action in response to the warning alert. Fatalism was also cited in focus groups as a reason for non-adherence with recommended countermeasures, but not as a reason for non-engagement with pre-incident communications.

It is clear that fatalism conflicts with the perceived efficacy of protective behaviours and represents an important barrier to preparedness for a nuclear emergency. However, the public might still engage with preparedness communications despite holding this attitude. Based on the findings of this research, it is clear that communications must show how a nuclear attack can be survived following the initial blast. It might be that risk communications cannot change the minds of all, but communications can have a positive effect nonetheless.

From previous literature:

In addition to the original finding that fatalism is a potential barrier to communication engagement, there is strong evidence from two studies in the review that explicitly cited fatalism as a barrier to preparedness (i.e. feeling unable to plan for the unknown) (Guterbock et al., 2010; Williams et al., 2005).

We can draw upon the wider health psychology field in exploring this. While fatalism has long been considered a barrier to adherence with treatment regimes, research has found that supporting patients to overcome feelings of powerlessness and to feel more in control regarding their own health behaviour has resulted in some considering fatalism a motivator of positive behavioural change in response to diagnosis and treatment planning wherein the individual feels there is nothing to lose from adhering to a treatment regime (Fairchild, 2015). Referred to as fatalistic-optimistic polarity, this may particularly be the case if we consider that in at least some cases, fatalistic talk has a social function, enabling emotional management of uncertainty and stress and allowing for acknowledgement of powerlessness to help us to make sense of the world (Keeley et al., 2009). Added information in preparedness communications such as survivability rates found in nuclear attack impact modelling studies (Buddemeier, 2010) may act as a motivator in this case.

6.2.6. Pre-existing knowledge of nuclear preparedness is low

From this thesis:

Little knowledge of protective actions was expressed by focus groups; feeling unprepared for nuclear attack was also expressed by most Hawai'ian and UK survey respondents. More than half of Hawai’i respondents said they had received no nuclear preparedness information; this rose to 80% in the UK. Approximately half of those who had received preparedness information felt it to have been sufficient. Also, regarding information sufficiency, focus groups living close to a nuclear plant had some knowledge of stable iodine but felt that the information included with it was inadequate.

Lack of awareness of actions that could be taken or of the effectiveness of protective actions was amongst reasons as to why no action was taken in response to the ballistic missile warning by many Hawai’i survey respondents.

From previous literature:

The importance of pre-existing knowledge was highlighted in the systematic review where acceptance of information during a nuclear disaster was found to be predicted by having agent-specific knowledge (Murakami et al., 2016; Perko et al., 2012).

Based on the outcomes of this research a specific recommendation as to nuclear preparedness risk information content can be made:

- To facilitate increased engagement, pre-incident communications should make transparent what preparedness UK authorities have in place. What is strongly evident is that this includes what a warning of imminent attack would look or sound like.

6.2.7. Recall is aided by multiple methods of distribution and information being ‘normalised’

From this thesis:

Two strong findings related to preferred distribution method: that no one method was preferred but instead the use of multiple methods was endorsed, and that information should be ‘drip fed’ into the public rather than distributed via a sudden, one-off information campaign. This method of drip-feeding related to information being embedded in institutions such as schools and the workplace. Focus groups felt that repetition of preparedness information over time would positively influence adherence. The example of attention being paid to unattended bags, despite the infrequency of this form of terror attack was cited. Pre-flight safety information was cited in reference to how easily protective actions are forgotten if given infrequently (i.e. only as often as one travels by air). Interestingly, respondents to the Hawai’i survey who reported having acted on preparedness knowledge cited recall of hurricane and tsunami protection. This suggests risk communications about different disaster-types can serve to reinforce each other. In this way, nuclear preparedness drills could be exercised much like fire drills. This was considered less alarming and more effective in engaging people, less overwhelming and aiding recall of information. Though not necessarily a one-off campaign, the public response to Protect and Survive seems to support this point of view. More recently a one-off 'grab bag' contents awareness campaign distributed by Scottish Police during a dedicated preparedness month (BBC, 2019) was met with suspicion and ridicule in the public and shows how preparedness communication can result in blowback. It should be noted that recall was not tested in this thesis.

Whilst social media was considered the least trustworthy source and method of communication, focus groups considered it not without benefits. For example, social media can be a starting point to verify information elsewhere and is an immediate method for distribution in the event of an attack. Survey and focus group participants also expressed a desire to see demonstrations of protective procedures on television or the internet.

From previous literature:

Embedding nuclear preparedness information in institutions did not arise in the previous literature, nor was 'drip-feeding' explored in the surveys. However, some original findings align with existing literature in the field, for example, the use of multiple sources resonates with review outcomes and the varying preferences for distribution method expressed by survey respondents. Leaflets/letters were one such preference, preferably personalised to the home owner and building type (UK survey; focus groups). This method was a preference in a study of nuclear plant information distribution (Malešič et al., 2015). Focus groups also considered the internet to be an appropriate online resource if used by credible sources (UK survey; focus groups), a finding shared by some studies in the systematic review (e.g. Guterbock et al., 2010; Williams et al., 2005).

Based on the outcomes of this research two specific recommendations as to information distribution can be made:

- There is strong evidence suggesting that to facilitate increased engagement, pre-incident communications should be distributed via multiple methods. Leaflets/letters should be personalised to the home owner and type of building and internet resources should allow for viewing of demonstrations of actions and procedures.
- To facilitate increased engagement, there is medium evidence to suggest that pre-incident communications should be embedded in institutions such as schools and workplaces. This might include introducing drills or educational seminars.

6.2.8. Instruction adherence in a nuclear emergency is low

From this thesis:

Only 8% of Hawai'i survey respondents actively sought immediate shelter in the minutes following the ballistic missile false alarm. Whilst few actually needed to seek shelter as they were already at home, this lack of adherence is likely to be in part due to a failure in messaging; message receivers were not told where to seek shelter or to stay at home if already there. Text responses in the survey suggest a lack of pre-existing knowledge of effective sheltering. This is echoed across phases of this study: non-adherence was suggested by focus group participants who did not believe their homes to be effective shelters (and by those perceiving sheltering to be counterintuitive in the review (Bass et al., 2015; Oak Ridge, 2011; Rogers et al., 2013)) or to not be a viable response due to desire to connect with loved ones.

From previous literature:

Anticipated adherence to a sheltering recommendation was also found in those with low confidence in local or national preparedness planning and those wishing to get supplies (Lasker, 2004; Miller, 1981; Nyaku et al., 2014). It would increase, however, if food and water could be delivered (Guterbock et al., 2010; Williams et al., 2005). Many studies in the review (Guterbock et al., 2010; Lasker, 2004; Malešič et al., 2015; Nyaku et al., 2014; Van Bladel et al., 2000; Williams et al., 2005) found collection of children to be a reason for sheltering non-adherence.

While a further original finding here was that focus groups also suggested self-evacuation to be unlikely due to perceived transport overburdening and fear of others' behaviour, for comparison, some studies reported on actual evacuation behaviour following the Three Mile Island disaster and found non-adherence occurred due to low perception of danger, fear of looting, waiting for an order to evacuate and believing oneself to be at a safe distance from the incident (Cutter and Barnes, 1982; Houts et al., 1980; Perry, 1981; 1983). Having received the advisory to evacuate, fear of harm, confusion and anticipation of a broader evacuation order with associated problems such as traffic gridlock were all reasons for adhering to the evacuation order (Cutter and Barnes, 1982). Altogether, this paints a picture of medium evidence (due to the lack in quality of the studies in question) for low intention to comply with recommended protective actions unless considered absolutely necessary, and only if considered feasible.

Based on the outcomes of this research a specific recommendation as to message content can be made:

- To facilitate increased adherence with protective instructions in the event of a nuclear attack, evidence is strong that messages should inform the public as to whether food and water could be delivered to those who are sheltering.

Based on this, and previous research, a further recommendation can be made:

- To facilitate increased adherence with protective instructions in the event of a nuclear attack, evidence is strong that messages should use basic terminology.

6.2.9. Recommended countermeasures are considered low in efficacy

From this thesis:

The belief that protective actions are largely ineffective in a nuclear attack was generally universal: UK survey respondents ranked building a shelter from furniture to be the least effective protective action from a list (getting underground was ranked most effective). Of course, this is likely to be true. However, an association was found between UK survey participants being more prepared if they felt sheltering to be effective. Importantly, focus groups felt that believing recommended actions to be ineffective diminished the potentially positive effect of trust in the communicating source.

From previous literature:

The original finding from the two surveys of increased preparedness when sheltering is considered effective provides an interesting comparison with previous literature as adherence with recommended countermeasures has also been found to increase, and fatalism decrease, where those actions were proven effective (Becker, 2004).

Based on this, and previous research, a specific recommendation as to message content can be made:

- To facilitate preparedness, evidence is strong that sources of pre-incident communications should make efforts to be relatable to the public, such as by ensuring recommended actions are widely considered to be effective.

6.2.10. There is no clear preference for communicating source

From this thesis:

The most frequently reported sources of preparedness information in surveys were local news media, workplace and educational institutions (Hawai'i), social media, friends/family, national news media and national government (UK). This is important since the only significant association related to source in surveys was UK participants being more likely to be intentionally prepared if they had received disaster preparedness information from emergency services. Emergency services were also amongst sources considered most trusted to provide nuclear risk communication.

In the focus groups, no clear preference for information source emerged. Instead participants highlighted the importance of an information source being relatable (as long as their advice was considered reasonable). Government sources were generally considered appropriate if their information was verified by a 'nuclear watchdog'.

From previous literature:

In the systematic review only one UK-based study reported on preferred risk communication source (any non-government: Pearce et al., 2013), and that study was exploring radiological device detonation.

Based on the present research, two specific recommendations as to message content can be made:

- To facilitate increased preparedness, evidence is medium that pre-incident communications should come from UK nuclear agencies, emergency services or the military. If distributed via the media or government sources messages should include verification by a 'nuclear watchdog'. This verification should include emphasis of the evidence base for given preparedness actions.
- To facilitate increased adherence with protective instructions in the event of a nuclear attack, evidence is medium that messages should come from UK nuclear agencies, emergency services or the military.

6.2.11. Trust in source is associated with adherence

From this thesis:

Across both surveys the most highly trusted sources to provide nuclear risk information were national government (including the Hawai'i Environmental Management Agency) and expert (nuclear) agencies. Online forums and social media contacts were rated lowest. In addition to nuclear agencies, UK survey participants also ranked emergency services and the military as sources whose advice participants would be most likely to comply with in relation to preparedness and protective actions in the event of a nuclear attack.

In contradiction to common understanding of trust in risk communication, it was interesting to see that the Hawai'i Environmental Management Agency was rated the most highly trusted from the list of options following their false alert. This supports the importance of pre-existing knowledge and experience in fostering trust. This may also speak to an outcome from focus groups that trust is not only fostered by what is said, but also by the source of information being able to show that they have the public's best interests at heart.

In focus groups a range of actions tailored to different scenarios was felt to increase faith in information. Trust alone is not enough, however. Even with highly trusted sources, adherence is also reliant on recommended actions appearing reasonable or evidence-based. For example, one focus group participant who had received preparedness messaging whilst living in a warzone felt it ineffective as it was not personalised to their circumstances.

It is important to remember that providing direct instructions for protection in the event of a radiation emergency is not the only purpose of pre-incident information. Perhaps equally important is educating regarding the nature of a nuclear bomb, providing reassurance to the public that their safety is being considered (which findings here suggest increases trust), increasing preparedness and setting expectations as to what might be instructed in the event (such as sheltering). Frewer et al. (1996) suggest sources gain or lose trust depending on ability to meet public expectations. The findings of this study provide some evidence to suggest that expectation setting is perhaps equally as important as preparedness actions, akin to normalisation of information. An argument perhaps exists that a change in focus regarding desired outcomes of pre-incident information is required: to informing of how authorities are preparing for such eventuality and expectation setting alongside enhanced instruction adherence.

From previous literature:

Acceptance of information during an incident was predicted by trust in the message source (e.g. Murakami et al., 2016; Perko et al., 2012) in the review, strongly suggesting trust to be important in health communications.

Whilst caution is needed in drawing comparison across the two surveys, and by proxy, in the review UK non-governmental sources (Pearce et al., 2013), the US President (Guterbock et al., 2010) and US public health departments (Nyaku et al., 2014) were amongst those rated highest for trustworthiness, while the nuclear industry (Belgium: Latré et al., 2018) and US government (Radiological Threat Awareness Coalition, 2008; Williams et al., 2005) were rated lowest. Such discrepancies suggest trust is based on pre-existing knowledge and experiences.

Consistency between messengers was found to increase trust (Rogers et al., 2013), as was perceived reliability (associated with the use of basic terminology), accuracy (i.e. consistency across messages) and effectiveness of recommendations (Becker, 2004; Prince-Embury, 1992ii).

Other than the retention of public trust in HI-EMA, the original findings certainly resonate with other health-related studies regarding protective behaviour. For example, Smith et al. (2017) found vaccine adherence to be associated with trust in the healthcare provider who recommends the vaccine and trust in the vaccine effectiveness.

Based on the present and previous research, several specific recommendations as to content and distribution can be made:

- To facilitate increased engagement, there is strong evidence that pre-incident communications should show how recommended actions can be effective, achievable or reasonable.
- To facilitate increased engagement, there is strong evidence that pre-incident communications should maintain honesty. This includes stating where there is uncertainty.
- To facilitate increased preparedness, there is strong evidence that pre-incident communications should ensure consistency across messages and between messengers.
- To facilitate increased adherence with protective instructions in the event of a nuclear attack, there is strong evidence that messages should be repeated but maintain consistency across messages and messengers.
- To facilitate increased adherence with protective instructions in the event of a nuclear attack, there is strong evidence that messages should make efforts to show that sources have the public's best interests as their primary concern. This can be achieved by providing reassurance that personal circumstances are accounted for in response advice.

Based on the previous literature, further recommendations can be made with regards to message content:

- To facilitate increased adherence with protective instructions in the event of a nuclear attack, there is medium evidence to suggest that messages should signpost to sources of verification which might be more trusted by certain groups.
- To facilitate increased adherence with protective instructions in the event of a nuclear attack, there is strong evidence that messages should ensure accuracy of recommended actions.

6.2.12. Parents are unlikely to shelter without their children

From this thesis:

Parental status was a commonly occurring influence on adherence in this research. UK survey participants with children under 18 years were more likely to be prepared. Prioritising the collection of, or simply being with children was a reason for non-adherence in focus groups despite an acknowledged risk to one's own health. Focus group members with children preferred evacuation to sheltering as a response action Desire to protect children was also cited as a reason for wanting pre-incident communications in the focus groups, although UK survey respondents with a child over 18 years old living at home were less likely to desire communications.

From previous literature:

There is much alignment between these original findings and the previous literature here. Parents with children under 18 are more likely disaster prepared (Guterbock et al., 2010; Williams et al., 2005); sheltering non-adherence is likely amongst parents (Becker, 2004; Nasar and Greenberg, 1984) although adherence may increase if people know that their children are safe (Lasker, 2004; Williams et al., 2005) and; evacuation is a preferred countermeasure (Kanda et al., 2013iii; Nasar and Greenberg, 1984; Prince-Embury, 1992ii; Zeigler and Johnson, 2010).

Based on the present and previous research, two specific recommendations as to message content can be made:

- To facilitate increased engagement, there is strong evidence to suggest that pre-incident communications should include how families can be protected if not together (such as advice around the collection of children from school) and how to communicate with loved ones.

- To facilitate increased adherence with protective instructions in the event of a nuclear attack, there is weak evidence to suggest that messages should provide information as to how children are kept safe if at school.

6.2.13. Communicating nuclear risk is unlikely to raise nuclear attack anxiety

From this thesis:

The emotional impact of preparedness is a common concern for policy makers in designing risk communications. Although no questions were explicitly asked about anxiety in this PhD, little anxiety was expressed in qualitative responses. (‘*why worry about something that you cannot control?’*). Some data regarding associated emotions was collected however. For example, in focus groups little fear of consequences was associated with lack of preparedness amongst participants. What’s more, risk reminders such as the distribution of nuclear risk communications, were considered unlikely to cause fear. In fact, fear was suggested to be relieved by the knowledge that the authorities are prepared to protect the public.

From previous literature:

While there have been studies that suggest anxiety to be a potential barrier in nuclear preparedness adherence (e.g. Becker, 2005), there is also medium evidence to suggest that communicating risk does not prompt fear or anxiety in the public (e.g. Gray and Ropeik, 2002; US Dept of Health and Human Services, 2002). In fact, under-response to public information campaigns is a more likely outcome than over-response in the form of excessive anxiety (Pearce et al., 2019). Not only this, but the more we trust the source the less we will experience fear (Lofstedt, 1996). Messaging that contains fear appeals (i.e. are designed to elicit fear) have been found to not be effective in motivating behavioural change (e.g. Reser and Bradley, 2017), perhaps unless accompanied by evidence of efficacy (Witte and Allen, 2000). Reser and Bradley (2017) outline communication approaches found in climate change research to elicit a stronger influence when they include: raising audience self-efficacy or sense of personal control; promoting a re-evaluation of cost-benefits and; outline effective low-cost alternative actions. This effect has been seen recently in response to the ‘Run, Hide, Tell’ campaign which aimed to prepare the public for a terrorist attack using a firearm (Pearce et al., 2019). This is not necessarily to be taken as a positive however: for people to pay attention to risk information they need to have a reasonably accurate representation of risk severity as well as their own susceptibility in order to motivate action (Rubin et al., 2012). We should remember that focus groups in this research were self-selecting and happy to discuss nuclear threats and so were not representative of the population. Care should therefore still be taken in drawing conclusions around anxiety and fear elicited from pre-incident communications.

6.3 Links to theory

6.3.1. Communication models

In Chapter 1 a brief outline of risk communication models was provided that have characteristics theorised to be relevant to this study. These were Learning Theory (Keselman et al., 2005), the Social-Cognitive Model (Lee and Lemyre, 2009), the Communication Persuasion Matrix (McGuire, 1989), the Extended Parallel Process Model (Witte, 1992; Witte & Allen, 2000) and Miletti and Peek's (2000) social psychology of public response to warnings theory. As will be explained here, these outcomes align closely with many of the central aspects of these models.

The central facet of Learning Theory that knowledge presented must reaffirm existing knowledge acquired through experience and cultural influence (mental maps) certainly aligns with the study outcome that risk communications should be embedded in institutions. This process of 'drip feeding' preparedness information by normalising it in society would allow for mental maps of nuclear preparedness to be formed, and might improve readiness for emergency risk communications, such as an instruction to shelter due to imminent attack.

The Social-Cognitive Model places perceived coping efficacy, perceived likelihood and front-line preparedness as central predictors of preparedness and information seeking related to terror risk. Much of this model aligns with outcomes of the present study: UK survey respondents who believed the government not to offer protection from nuclear attack were less likely to be personally prepared. However, focus groups expressed an opinion that front-line preparedness was a reason to not require personal preparedness. Those perceiving there to be a high risk of nuclear attack were also more likely to be prepared. Contrary to the model however, these individuals were also less likely to desire risk information. Information was also not required by those who felt preparedness was low in effort (suggesting high perceived coping efficacy). Worry, experienced as a consequence of cognitive evaluations (such as of coping efficacy) did not appear to be a factor in this study. Having been developed to target public communications regarding CBRN terror, it appears that there is much overlap between predictors of behaviour in The Social-Cognitive Model and associations between predictors and behaviour in the present study which suggests this model to be an appropriate fit for pre-nuclear risk communications development.

Adjusting messaging to address the public's perception of risk is also a central factor in eliciting a desired outcome from risk communication in the Communication Persuasion Matrix, as well as Covello's four organising models. In this study the input variables outlined by this model were explored and no clear preference for source, message and channel was found. These are aspects that are likely to be dictated by Covello's *trust determination*, found here to be important in eliciting adherence, but not as important as perception of risk, and of the desired outcome (the fifth input of the Communication Persuasion Matrix) being perceived to be a reasonable and effective protective measure.

Coping efficacy is also an important factor in acceptance of fear inducing messages in the Extended Parallel Process Model. In this case, low self-efficacy and fatalism were barriers to acceptance of pre-nuclear incident messaging, in-line with the model. This is defined as reactance (Brehm and Brehm, 1981), and was manifested in the UK-based survey as denial that a nuclear attack could occur against the UK.

The final model of risk communication discussed, Miletti's social psychology of public response to warnings, relates largely to emergency risk communication response, and so data from the Hawai'i survey will be drawn upon. Following Miletti's five stages we see that most of the Hawai'i public heard the warning as it was sent via a method instantly accessible to most. A problem came at the second stage however; many people did not understand from the warning that their own homes were a suitable shelter and remaining at home was a consequence of not knowing what else to do, despite understanding what the overall risk being communicated was. This research showed that around half of the warning recipients believed there to be an immediate risk to themselves. This suggests personalisation of that risk, the fourth stage. The final stage, performing the desired behaviour was found to be undertaken deliberately by very few, however, as discussed, situational factors (being at home already) meant that the desired behaviour was passively undertaken by most.

6.3.2. Underpinning methodological framework

The theories outlined above each provide elements that appear to inform nuclear risk communications development in the context of the outcomes of this research. At the outset of this thesis it was decided that a framework to underpin the methodology might aid in understanding the underlying mechanisms behind behaviour change towards a more disaster prepared public. Theoretical Domains Framework (TDF) was selected to provide this function. TDF was informed by public health research and has not previously been used to inform the development of a behaviour change intervention related to any form of CBRN agent preparedness. This framework has guidance (Atkins et al., 2017) for conducting research aimed at developing a behaviour change intervention. This is achieved by understanding influences on behaviour in the context in which those behaviours occur. In this research, it provided a checklist for ensuring that influences on behaviour change were accounted for during data collection. Not all domains included in the framework were relevant and refinement of the scope of this research across phases reflects this. However, the Framework was effective in identifying domains that appear to be important in the development of effective nuclear risk communications that are aimed at influencing preparedness behaviour. These are reflected in Table 6.1.

In Chapter 1, the TDF was introduced in the context of knowledge mobilisation, or, applying the scientific process in a way that can enable guidance to be operationalised by a non-scientific audience. Also introduced in Chapter 1 was a model representative of factors central to communication and behaviour change. Using the outcomes of this thesis within the TDF framework, this model can be updated and a guiding framework for pre-nuclear incident communications be proposed. Domains of the TDF found to be important for nuclear risk communication (discussed above) that correspond with aspects of the previously outlined risk communication models are beliefs about capabilities (self-efficacy), beliefs about consequences (risk perception), knowledge (mental maps) and memory, attention and decision processes (social psychology of warning response). It may be that the other domains: social or professional role identity, emotion, environmental context and resources and social influences also overlap. Without further exploration it is difficult to know.

TDF alone does not provide a statement as to the structural and psychological processes that regulate behaviour change and while not developed to target risk communication development directly, it has been valuable in this research process. Identification of important behaviour change domains can allow for mapping onto existing models to identify which model might best explain how to communicate with the public about nuclear risk. It can also be used alongside the COM-B (Cane et al., 2012; Michie et al., 2014), a further refined model of behaviour in which capability, opportunity and motivation interact and which is used to develop testable interventions.

Table 6.1. *Research outcomes mapped to TDF domains*

Domain	Example construct	Illustrative example from this study
Memory, attention and decision processes	Cognitive overload; attention control; decision making	Survey respondents wished to receive information on preparedness and protective actions prior to an attack being imminent. In the event, cognitive overload is more likely; risk communication embedded in society would make it easier to recall if needed (focus groups)
Social / professional role identity	Social identify; group identity	Focus groups who would access risk information on social media would look to groups that fit their social identity (e.g. mums groups); in one previous study young males were found to seek out peers to verify risk information (Bass et al., 2015)
Knowledge	Knowledge of scientific rationale; procedural knowledge	Agent-specific knowledge has been associated with acceptance of nuclear preparedness messaging (Perko et al., 2012), however in the Hawai'i survey, believing an attack was imminent upon receipt of the missile alert was associated with having not received preparedness information or not believing information to have been sufficient
Beliefs about consequences	Outcome expectancies; attitudes; beliefs	Focus groups expressed a belief that sheltering would mean longer time spent suffering following nuclear attack
Emotion	Anxiety; fear; stress	Fear was not resultant of lack of preparedness amongst focus groups; knowing that authorities are prepared to protect the public was suggested to relieve anxiety
Environmental context and resources	Environmental stressors; resources; barriers and facilitators; person x environment interaction	Ability to evacuate based on transport overcrowding was an influence on adherence to protective actions across focus groups and surveys
Beliefs about capabilities	Perceived competence; self-efficacy; beliefs	Adherence was reliant on focus groups' ability to carry out actions 'properly' and receiving assurance that personal circumstances were accounted for; low self-efficacy was linked with fatalism and reduced engagement with communications in focus group and survey outcomes
Social influences	Social and group pressure/ norms/ support	Observing other's behaviour, such as non-adherence to sheltering was cited as an influence of behaviour in focus groups, surveys and previous literature (e.g. Lasker, 2004)

6.3.2.1. Model of key nuclear attack preparedness ingredients

Using the outcomes of this thesis, the model proposed in Chapter 1 can be updated (figure 6.1) and is presented here as an 'ideal world' scenario in which a full understanding of context, psychology and communication principles allows communicators to craft the characteristics of their messages in order to affect pre-incident preparedness behaviours and also behaviour in the event of an incident.

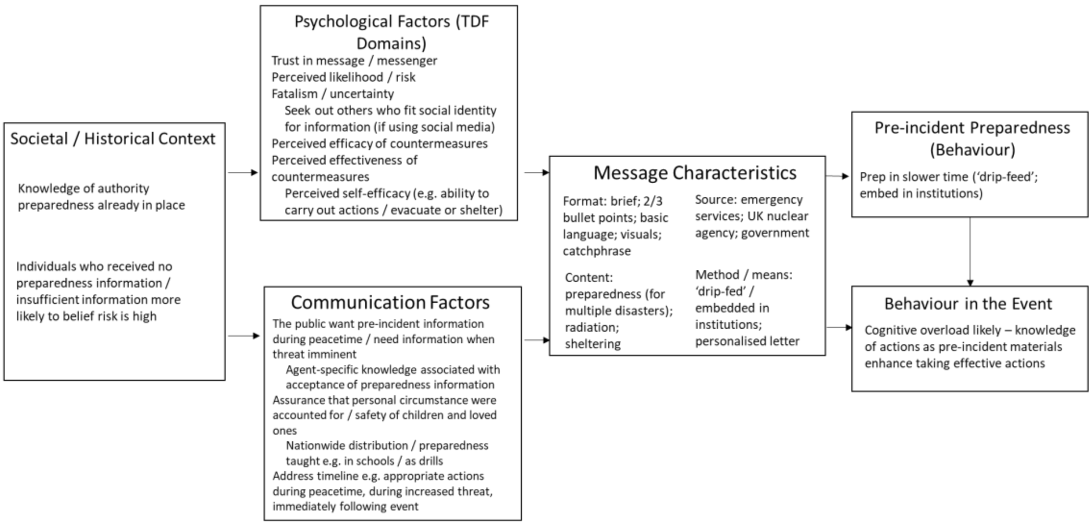


Figure 6.1. Updated model representation of factors known to contribute to effective communications targeted at behaviour change in the context of nuclear catastrophe preparedness.

6.4. Key lessons learned

Throughout this thesis, lessons have been learned regarding how agencies might communicate with the public to enable enhanced preparedness for a nuclear catastrophe. Here these lessons are restated as guiding principles for agencies charged with providing preparedness information.

- Communications should be distributed by, or labelled as coming from, emergency services as these are considered amongst the most trustworthy and most likely to prompt preparedness actions being taken. Otherwise no clear preference for communicating source was expressed, though the military, UK nuclear agencies and the Government with a 'nuclear watchdog' verification were considered appropriate.
- Pre-incident communications aimed specifically at nuclear catastrophe preparedness should be framed around the key informational elements of preparedness instructions, recommended countermeasures and facts about radiation. In particular, information about why different countermeasures (sheltering; evacuation) might be ordered in the event would be helpful. However, preparedness communications designed to encapsulate a range of disaster-types may have wider acceptance and engagement. Further items for inclusion in nuclear-specific communications are outlined below.
- Pre-incident communications distributed as written materials should be brief, using basic terminology and formatted to include visuals with two or three central

instructions such as using bullet points or elements that capture attention (such as using a catchphrase).

- Recommended preparedness actions and countermeasures to take in the event should be shown to be effective, achievable and reasonable. Communications should be honest (such as by stating where information is unknown in the event of a nuclear catastrophe) and consistency through repetition across messages and messengers, with reassurance that the public's safety and survival is at the centre of all communications to facilitate trust in the message and messenger.
- Sheltering is shown to be effective at certain distances from a nuclear blast as a protective measure (when escape is not an option). Furthermore, the public appear to consider this reasonably efficacious under these circumstances also. The efficacy of sheltering should be highlighted in communications to confirm the fact for those already confident in sheltering as a countermeasure, and to inform those who are not previously aware of this.
- Many people, particularly parents, are likely to ignore instructions that require isolation (such as sheltering) in favour of seeking out loved ones. The safety and protection of children, such as sheltering in school, should be highlighted in communications to discourage people from putting themselves in danger.
- Timeline issues should be highlighted in communications. Particularly this includes what communications might be received (and how) at different stages of the timeline: for example, information may be 'drip-fed' during periods of low threat, but swiftly distributed such as via social media at a time of imminent threat. Additionally, appropriate preparedness actions at different stages of the timeline should be outlined: for example, at a time of low threat appropriate actions include gathering first aid supplies and bottled water, whereas sheltering or evacuation (as instructed) are appropriate at a time of increased threat or continued sheltering following a release of radiation (including whether supplies could be delivered to those sheltering or whether extended sheltering should also be prepared for).
- From Hawaii we can see that there needs to be prior knowledge among the public as to what warnings will look or sound like, as well as having knowledge of key terms that would be used in preparedness communications and how these can be actioned (e.g. shelter).

6.4.1. Knowledge mobilisation

Using these details, guidance for knowledge mobilisation can be proposed (figure 6.2) which also addresses issues of timeline referred to in Chapter 1. While not a framework, it does illustrate practical guidance to facilitate knowledge mobilisation and how policy makers need to be aware that different things are important at different time points:

During a period of no known (or non-immediate) threat: sources such as the UK Government, emergency services and/or UK nuclear agencies should embed messaging into existing institutions and/or send personalised letters or leaflets to households. These methods should include two to three simple instructions as to what to do to prepare for a nuclear attack, including what actions to take in the event of an impending attack. Specifically, this should include information regarding sheltering, preparedness actions and the nature and effects of radiation (agent specific information). Attention should be given to ensuring that the public are aware that advised actions are effective in protecting many people potentially in the range of a nuclear explosion and its fallout and how they are achievable. If appropriate, the preparedness and protective actions of authorities should also be detailed.

When a threat is known to be imminent: Those same sources as above should provide a brief message which reaffirms the central message(s) of preparedness messaging and necessary immediate actions (e.g. take shelter). This should be delivered via immediate warning systems (e.g. alarms, social media, SMS). Communicators should be aware the public in this instance may take social cues such as waiting to see what actions are taken by friends and neighbours and may be more accepting of warnings when coming via sources that align with their own social identity. Further, cognitive overload is possible due to the magnitude of information. This reinforces the need for information at this stage to be brief and specific.

Immediately following the incident: On going reminders of the information previously received will be required during the immediate aftermath of a nuclear explosion (e.g. to continue sheltering). Communicators should be aware that social influences are likely to persist during this time which can be a n additional influence on the public's behaviour.

During no known threat (peacetime)

Knowledge – agent-specific information to increase acceptance

Knowledge – inform as to what warning may look / sound like in the event

Beliefs about capabilities – ensure the efficacy and achievability of actions are highlighted / personal circumstance accounted for in advice

Emotion – inform as to the preparedness capabilities of authorities

Method – personalised letters / embedded nuclear preparedness in institutions

Content – preparedness; sheltering radiation

Format – 2/3 simple instructions; basic language; brief; visuals

Source – emergency services; UK nuclear agencies; Government

When threat is known (imminent)

Decision making – cognitive overload likely; public must attend to relevant information to undertake most effective actions.

Social identity – seek out information from sources who fit social identity

Environmental context / resources – advise as to the most effective action to take (e.g. sheltering if evacuation not possible)

Social influences – observing other's can be an additional influence on behaviour

Method – immediate distribution method (alarm; social media)

Content – immediate actions

Format – brief message re-affirming central preparedness message (e.g. take shelter)

Source - Source – emergency services; UK nuclear agencies; Government

Following incident

Recall / reminder of information previously received (e.g. sheltering guidance)

Social influences – observing other's can be an additional influence on behaviour

Figure.6.2 Framework for knowledge mobilisation of pre-nuclear incident preparedness communications (Communications following nuclear catastrophe was not addressed in this thesis but is included in this framework for illustrative purposes)

6.5. Next steps and research agenda

The following table (6.2.) lays out a research agenda for continuing the development of effective pre-incident nuclear catastrophe communications. These points are expanded upon below.

Table 6.2. *Research agenda for next steps and identifying gaps*

Step	Example research questions	Example research design
Design messages	What message designs provide the most effective impact? (e.g. content, source, delivery method); What should messages look like during peacetime? What should messages look like when the threat is imminent?	Qualitative methods (focus groups; workshops) using specific nuclear attack messages along with generic disaster-risk preparedness messages. Participants asked to rate and discuss messages on aspects such as clarity, perceived effectiveness / efficacy of recommended actions
Test messages	What format of message has the most effective acceptance and retention rate?	RCT to test content and trust in recommendations (experimental group receive a message that is personalised to their circumstances (i.e. specific to their type of housing, mentioning local landmarks that might be targeted); control group rates a generic message for the same variables)
Evaluate messages / Identify gaps in knowledge	What is the effect of using social media to distribute preparedness messaging?; Can message recipients accurately recall and relate key elements of preparedness advice at various timelines following receipt?; Is there a detrimental long-term impact on messaging if the event that is prepared for does not come to pass; What level of impact does trust in the source have on a practical level?	Survey to establish the benefits of using social media for distribution (reach, trust etc) with repeated surveying to test recall and uptake of recommendations across a timeline (i.e. did initial preparedness steps diminish over time?)

The next stage in the development of effective pre-nuclear incident communications is to use the recommendations presented here to design, test and evaluate messages. Aside from this, gaps emerged from the literature that if explored, would also complement our understanding of effective public communication in the pre-incident phase.

One gap relates to use of social media in nuclear emergency communications. During a disaster social media use has been found to increase (Pew, 2006; Rainie, 2005) particularly during the immediate period (Thelwall & Stuart, 2007). This was seen during the Hawai'i ballistic missile false alert where screenshots of the warning were widely shared on Twitter with users looking for corroboration. Studies have shown that in high pressure situations individuals are able to convey key elements of messages relating to protective actions and that content, style and previous exposure of messages influence re-Tweeting on that platform (Sutton et al., 2014). Though social media was considered the least trustworthy source of information in this research, some cited it as being a way into nuclear preparedness education wherein information viewed could be verified elsewhere. It is unclear to what extent social media could be used to disseminate and promote communications during the pre-incident phase.

Secondly, more data are needed on how different information sources can foster trust in the public. Trust is central to whether information is accepted, and recommended actions adhered to. Few studies have explored the facilitation of trust, or distrust, when the information being communicated has existential connotations. Indeed, it was suggested here that trust is secondary to perceived efficacy of recommendations. In a nuclear attack, the public's perception of countermeasure effectiveness will differ from that of a smaller scale or isolated CBRN incident. Not only this but sources of information considered most likely to foster the greatest adherence in undertaking protective actions in this research were not necessarily the sources identified in the previous literature as being most trustworthy. For example, Wray and colleagues (2006) concluded in their large-scale Pre-event Messaging Project that local sources are most trusted and should be used to disseminate messaging originating from national government. However, local sources were not considered in the same way here; these findings suggest nationwide distribution is preferred. However, participants in this research also desired information particular to their circumstance which would perhaps be impossible to achieve on a nationwide scale. This should be explored further, perhaps using a randomised control trial in which groups rate a message for its content and their trust in its recommended actions that are personalised to their circumstances (i.e. specific to their type of housing, mentioning local landmarks that might be targeted), and a control group rates a generic communication for the same variables.

The longer-term impact of any information campaign is a third key knowledge gap. Hopefully, any pre-event messages that are disseminated will never need to be used. However, maintaining knowledge over time is important. To date, studies have generally only focused on the immediate impact of messages. Whether messages about high impact events which do not come to pass have a wider, detrimental, effect on the credibility of future messages on related issues is largely unknown (Rubin et al., 2005) though Glik (2007) suggests risk communications advocating preparedness for a non-imminent disaster are less successful in motivating behaviour change than communications in an emergency. Of course, non-imminent disasters are not necessarily those that do not come to pass so this comparison is perhaps arbitrary. However, this may present another challenge for communicators nonetheless, and the frequency with which messages need to be repeated and reinforced is an area worthy of further investigation.

In this research situational factors that facilitate or present a barrier to message engagement and preparedness were reported on. Demographic data were also tested for associations in the surveys. However, humans are social beings, so it may be that additional influences on engagement and adherence exist that our cognitions and beliefs do not account for. For example, two studies in the review reported on community attachment as a factor in willingness to adhere (Guterbock et al., 2010; Williams et al., 2005). While some focus group members commented on a lack of attachment to their city, this was not explored further in terms of adherence. Social identity was a domain of the TDF that arose frequently during the review suggesting the potential importance of social factors that are worthy of further research. Socio-economic status is another: Protect and Survive was criticised as being elitist as assumptions about household-types and resources were suggested to lead to inequities in patterns of survival (Preston, 2014). A further two areas which have had little or no attention in risk communication research are engagement with preparedness messaging among people with disabilities and language deficit. Non-native speakers particularly have been found to worry that they will miss vital information which can affect preparedness and adherence (Bass et al., 2016i). Exploration of the comprehension of vital preparedness and protection terms should be undertaken in recipients for whom English is not a first language.

6.6. Conclusion

The UK public may be more prepared for a nuclear catastrophe than previously thought. Measures taken for general disaster preparedness have some overlap with those recommended for nuclear disaster. However, factors such as fatalism towards a nuclear attack reduce people's intention to further prepare and, due to low perception of countermeasure effectiveness, there is also little intention to adhere to instructions to shelter amongst the public, should the UK be attacked with a nuclear weapon.

Whether the UK public would accept and engage with pre-nuclear incident communications designed to heighten preparedness and increase knowledge of protective actions to take in the event is unclear. The desire for preparedness information is strong in those surveyed. However, we see that those who believe the risk of nuclear attack is high, those who believe sheltering to be an effective countermeasure and those who believe that preparedness is low in effort are less likely to be receptive of such information. Moreover, the data suggests there to be low perception of countermeasure effectiveness against catastrophic nuclear attack overall, a further factor to cause disengagement with pre-incident communications. The natural follow on from this research is to design a preparedness communication and measure changes in actual preparedness and any increased knowledge of nuclear attack countermeasures.

Several recommendations have been made as to how pre-nuclear incident communications might be most effective in influencing engagement with messaging, preparedness and adherence to instructions in the event. These include communications coming from emergency services, nuclear agencies or the military, using multiple methods or being embedded in institutions such as initiating nuclear drills in schools and workplaces, and offering recommendations for a range of disasters, not solely nuclear.

Ultimately, risk communications are used to help the public understand risk and make informed decisions, though messaging will not reach everyone. Neither will messaging influence the behaviour of all who are reached. This may particularly be the case in high impact, low likelihood events such as nuclear attack. However, this research has shown that preferences do exist for risk communications and it is likely that where information converges with the perceptions of the target audience it can enhance preparedness in the public, and ultimately, save lives.

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Appendix A. Full Systematic Review search strategy

The following databases were searched for relevant publications: Medline (via OVID, Epub ahead of print (January 16 2017); In-Process and Other Non-Indexed Citations, Ovid MEDLINE (R) Daily and Ovid MEDLINE (R) (1946 to present) search conducted 17th January 2017); Embase (via OVID, 1974 to 2017 January 16) search conducted 17th January 2017; PsycINFO (via OVID, 1806 to January Week 2 2017) search conducted 18th January 2017; Web of Science (core collection) search conducted 20th January 2017.

Database: Ovid MEDLINE(R) <Epub ahead of print (January 16 2017), In-Process and Other Non-Indexed Citations, Ovid MEDLINE (R) Daily and Ovid MEDLINE (R) (1946 to present)>

Search Strategy:

1	Fukushima / (2122)
2	exp Radioactive Hazard Release/px (Psychology) (107)
3	Fukushima .kw (110)
4	Chernobyl / (5450)
5	Chernobyl .kw (61)
6	Chenobyl / (2)
7	Chenobyl .kw (0)
8	"Three Mile Island" / (191)
9	"Three Mile Island" .kw (1)
10	Hiroshima / (2025)
11	exp Nuclear Warfare/px (Psychology) (18)
12	Hiroshima .kw (3)
13	Nagasaki / (1698)
14	Nagasaki .kw (4)
15	Sellafield / (322)
16	Sellafield .kw (5)
17	Windscale / (67)
18	Windscale .kw (0)
19	Kyshtym / (51)
20	Kyshtym .kw (0)

21	Fukui / (669)
22	Fukui .kw (1)
23	Tokaimura / (11)
24	Tokaimura .kw (0)
25 - 30	(Nuclear adj release (33) or accident* (1140) or disaster* (307) or attack* (105) or terror* (114) or emergenc* (167)) .ab,ti,kw.
31	exp Nuclear Weapons /hi (History) (77)
32	"Radioactive Fallout"/ (4061)
33	"Radioactive Fallout" .kw (644)
34	25 or 26 or 27 or 28 or 29 or 30 (1774)
35	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 31 or 32 or 33 or 34 (15253)
36	"Dirty Bomb" / (93)
37	"Dirty Bomb" .kw (3)
38	"Radiological Dispersion Device" / (18)
39	exp Disaster Planning/hi, mt, td (History, Methods, Trends) (2155)
40	"Radiological Dispersion Device" .kw (0)
41	"Radiological Weapon" / (6)
42	"Radiological Weapon" .kw (0)
43 - 48	(radi* adj5 (accident* (2934) or release (5405) or disaster* (204) or attack* (1583) or terror* (330) or emergenc* (3328))) .ab,ti,kw.
49	Goiania / (459)
50	Goiania .kw (0)
51	Litvinenko / (24)
52	Litvinenko .kw (0)
53	"Polonium 210" / (302)
54	"polonium 210" .kw (11)
55	43 or 44 or 45 or 46 or 47 or 48 (13207)
56	36 or 37 or 38 or 39 or 40 or 41 or 42 or 49 or 50 or 51 or 52 or 53 or 54 or 55 (16048)
57	Shelter* / (10062)
58	Shelter* .kw (220)
59	"Duck and Cover"/ (7)

60	"Duck and Cover" .kw (0)
61	evac* / (20396)
62	evac* .kw (115)
63	relo* / (14588)
64	relo* .kw (120)
65	Iodine/re (Radiation Effects) (18)
66	Behav* / (1532356)
67	Behav* .kw (27776)
68	Psych* / (1369475)
69	Psych* .kw (70765)
70 - 72	(respon* adj3 crisis (625) or emergenc* (5315) or public (4638)) .ab,ti,kw.
73	adhere*/ (196883)
74	adhere*.kw (3624)
75	engage*/ (127855)
76	engage*.kw (488)
77	comply/ (9519)
78	comply.kw (1)
79	compliance/ (152734)
80	compliance.kw (1333)
81	communicat*/ (373405)
82	communicat*.kw (8136)
83	Warning*/ (22296)
84	Warning*.kw (132)
85	instruct*/ (94562)
86	instruct*.kw (320)
87	70 or 71 or 72 (10578)
88	57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 (3307960)
89	35 or 56 (29685)
90	88 and 89 (3776)

Appendix B. Systematic Review outcome tables

Table B1. Downs and Black (1998), risk of bias checklist (adapted). Scoring: yes=1, no=0, unable to tell=0.

	Score	20	19	19	19	19	18	18	17	17	17
Power	Sufficient power to detect a clinically important effect?	5	5	5	5	5	5	5	5	5	5
	Adequate adjustment for confounding in analyses?	1	1	1	0	0	0	0	0	0	0
Internal validity - confounding (selection bias)	Was the randomised intervention assignment concealed?	0	0	0	1	0	0	1	0	0	0
	Were cases and controls recruited over the same period of time?	1	1	1	1	1	1	1	1	1	1
	Were different intervention groups used or was recruitment from same population?	1	1	1	1	1	1	1	1	1	1
	Main outcomes valid and reliable?	1	1	1	1	1	1	1	1	1	1
Internal validity - bias	Statistical tests appropriate?	1	1	1	1	1	1	0	1	1	1
	16. If 'data dredging' was this made clear?	1	1	1	1	1	0	1	1	0	1
External Validity	Subjects prepared to participate representative population?	1	0	0	1	1	1	1	1	1	1
	Subjects asked to participate representative of population?	1	1	1	1	1	1	0	1	1	1
Reporting	Probability values reported except where value is less than 0.001?	1	0	0	1	0	0	0	0	0	0
	Estimates of random variability?	1	1	1	0	1	1	1	0	1	0
	Main findings described?	1	1	1	1	1	1	1	1	1	1
	Distributions of principal confounders described?	0	1	1	0	1	1	1	0	0	0
	Interventions described?	1	1	1	1	1	1	1	1	1	1
	Characteristics of patients described?	1	1	1	1	1	1	1	1	1	1
	Main outcomes to be measured clearly described?	1	1	1	1	1	1	1	1	1	1
	Aim / objective described?	1	1	1	1	1	1	1	1	1	1
	Ref.	Bass et al., 2015	Guterbock et al., 2010	Rubin et al., 2012	Latré et al., 2018	Bass et al., 2016i	Bass et al., 2016ii	Taylor et al., 2011	Murakami et al., 2016	Vyncke et al., 2016	Rogers et al., 2013

	Score	17	17	17	17	17	17	16	16	16	16
Power	Sufficient power to detect a clinically important effect?	5	5	5	5	5	5	5	5	5	5
	Adequate adjustment for confounding in analyses?	0	0	0	0	0	0	0	0	0	0
Internal validity - confounding (selection bias)	Was the randomised intervention assignment concealed?	0	0	0	0	0	0	0	0	0	0
	Were cases and controls recruited over the same period of time?	1	1	1	1	1	1	1	1	0	1
	Were different intervention groups used or was recruitment from same population?	1	1	1	1	1	1	0	1	0	1
	Main outcomes valid and reliable?	1	1	1	1	1	1	1	1	1	1
Internal validity - bias	Statistical tests appropriate?	1	1	1	1	1	1	1	1	1	1
	16. If 'data dredging' was this made clear?	1	1	0	1	1	1	1	1	1	1
External Validity	Subjects prepared to participate representative population?	0	0	1	1	1	0	1	1	1	1
	Subjects asked to participate representative of population?	1	0	1	0	1	1	1	1	1	0
Reporting	Probability values reported except where value is less than 0.001?	1	1	0	0	1	1	0	0	0	1
	Estimates of random variability?	0	1	1	1	0	0	0	0	1	0
	Main findings described?	1	1	1	1	1	1	1	1	1	1
	Distributions of principal confounders described?	0	0	0	0	0	0	0	0	0	0
	Interventions described?	1	1	1	1	1	1	1	1	1	1
	Characteristics of patients described?	1	1	1	1	1	1	1	0	1	0
	Main outcomes to be measured clearly described?	1	1	1	1	1	1	1	1	1	1
	Aim / objective described?	1	1	1	1	0	1	1	1	1	1
Reporting	Ref.	Zwolinski et al., 2012	Prince-Embury, 1992i	Prince-Embury, 1991	Perko et al., 2014	Hellier et al., 2014	Becker, 2004	Lee & Lemyre, 2009	Lasker, 2004	Pearce et al., 2013	Kanda et al., 2013ii

	Reporting								External Validity		Internal validity - bias		Internal validity - confounding (selection bias)				Power		
Ref.	Aim / objective described?	Main outcomes to be measured clearly described?	Characteristics of patients described?	Interventions described?	Distributions of principal confounders described?	Main findings described?	Estimates of random variability?	Probability values reported except where value is less than 0.001?	Subjects asked to participate representative of population?	Subjects prepared to participate representative population?	16. If 'data dredging' was this made clear?	Statistical tests appropriate?	Main outcomes valid and reliable?	Were different intervention groups used or was recruitment from same population?	Were cases and controls recruited over the same period of time?	Was the randomised intervention assignment concealed?	Adequate adjustment for confounding in analyses?	Sufficient power to detect a clinically important effect?	Score
Gerber et al., 2006	1	1	1	1	0	1	0	1	0	1	0	1	1	1	1	0	0	5	16
Cutter & Barnes, 1982	1	1	1	1	0	1	0	1	1	1	0	1	1	1	0	0	0	5	16
Williams et al., 2005	1	1	1	1	0	1	1	0	1	1	0	0	1	1	1	0	0	5	16
Prince-Embury, 1992ii	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1	0	0	5	15
Kanda et al., 2013iii	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1	0	0	5	15
Lemyre et al., 2007	1	0	1	1	0	1	1	0	1	0	0	1	1	1	1	0	0	5	15
Malěsič et al., 2015	1	1	0	1	0	1	0	1	1	0	1	1	1	1	0	0	0	5	15
Kanda et al., 2013i	1	1	1	1	0	0	0	1	0	1	0	1	1	1	1	0	0	5	15
Nasar & Greenburg, 1984	1	1	0	1	0	1	0	0	0	0	1	1	1	1	1	0	0	5	14
Carini, 2011	1	0	1	1	0	1	0	0	1	0	0	1	1	1	1	0	0	5	14

	Reporting								External Validity		Internal validity - bias		Internal validity - confounding (selection bias)				Power		
Ref.	Aim / objective described?	Main outcomes to be measured clearly described?	Characteristics of patients described?	Interventions described?	Distributions of principal confounders described?	Main findings described?	Estimates of random variability?	Probability values reported except where value is less than 0.001?	Subjects asked to participate representative of population?	Subjects prepared to participate representative population?	16. If 'data dredging' was this made clear?	Statistical tests appropriate?	Main outcomes valid and reliable?	Were different intervention groups used or was recruitment from same population?	Were cases and controls recruited over the same period of time?	Was the randomised intervention assignment concealed?	Adequate adjustment for confounding in analyses?	Sufficient power to detect a clinically important effect?	Score
Van Bladel et al., 2000	1	0	1	0	0	1	0	0	1	0	1	0	1	1	1	0	0	5	13
Perko et al., 2012	1	1	0	1	0	1	0	0	0	0	1	1	1	0	1	0	0	5	13
Oak Ridge, 2011	1	0	1	0	0	1	0	1	0	0	1	1	1	0	0	0	0	5	12
Houts et al., 1980	0	1	1	1	0	1	0	0	0	1	1	0	1	0	0	0	0	5	12
Nyaku et al., 2014	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1	0	0	5	12
RTAC, 2008	0	0	1	0	0	1	1	0	1	0	0	0	1	1	1	0	0	5	12
Zeigler & Johnson, 2010	1	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	5	11
Pheby & Robinson, 1990	0	0	0	1	0	1	0	0	1	0	0	0	1	1	1	0	0	5	11
Miller, 1981	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	5	10
Perry, 1983	1	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0	0	n/a	7
Perry, 1981	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	3

Table B2. ***Predictors of behaviour in preparation for a radiation emergency (significant effects in bold)***

		Risk of bias score
Information Seeking	• **Studies involving hypothetical scenarios**	
	Lee & Lemyre (2009). (QN) **Predictors: perceived probability (β=0·16, t=4·88, p<0·001), perceived personal impact (β=0·08, t=1·93, p=0·05), coping efficacy (β=0·10, t=3·43, p<0·001), worry (adjusted R2=0·05, F(3, 1096)=21·80, p<0·001, with β=0·19, t=6·22, p<0·001); negatively associated with perceived seriousness (β=-0·08, t=−2·05, p<0·05);** perceived government or front-line preparedness not significant	16
	• **Studies involving actual events or published communication materials**	
	Prince-Embury (1991). (QN) Information seekers near TMI were more highly educated and male but not necessarily those reporting most worry (effect not reported)	17
Preparedness	• **Studies involving hypothetical scenarios**	
	RTAC (2004). (QL; QN) 63% not feeling prepared for RDD attack; 36% stocked food, 35% water	12
	Lee & Lemyre (2009). (QN) Predictors: **perceived probability (β=0·25, t=7·98, p<0·001), perceived coping efficacy (β=0·06, t=2·15, p<0·05), perceived front-line preparedness (β=0·15, t=4·06, p<0·001)**; worry (adjusted R2=0·05, F(3,1096)=21·95, p. <0·001, with β=0·25, t=8·10, p<0·001). Perceived seriousness, governmental preparedness, self-efficacy, personal impact not significant	16
	Lemyre et al. (2007). (QN) **Older respondents more likely to have emergency supply kit (F(1, 827)=12·16, p<·001); urban area residents established emergency plans (F(1, 1438)=4·34, p<·05), put together emergency supply kit (F(1, 1438)=6·50, p<·05), obtained information about potential shelters (F(1, 1438)=4·73, p<·05) to lesser extent than rural residents; less educated respondents received first aid or CPR training to a lesser extent (F(1, 1430)=9·17, p<·01)**	15
	Malěsič et al. (2015). (QN) Few preparedness behaviours due to belief nuclear sites are safe/ in emergency there would not be time to evacuate (effect not reported)	15
	Nyaku et al. (2014). (QN) ~85% had 3-day supply of non-perishable food, 76·4% a way to cook without utilities; 64·7%a 3-day supply of drinking water; 67·1% prepared a first-aid kit, (among households with medication users) 62·8% had a 7-day supply	12
	Guterbock et al. (2010). (QN) 39·8% had some preparedness plans including respondents who experienced an event that caused them to stay at home or to evacuate, more highly educated, those with children <18, older respondents (effects not reported); differences regarding race, geographic location, income not significant; barriers to preparedness: denial/ unwillingness (21·7%), other priorities (16·6%), lack of time (15·4%), no reason (12·3%), cant plan for unknown/ fatalism (10·1%), 'don't know what to do' (9·3%), lack of money/ resources (2·6%)	19
	Williams et al. (2005). (QN) 27·3% stored food for >10 days, 31% 6-10 days, 15·3% <6 days, 27·1% none; 20·9% water stored for >10 days, 17·3% 6-10 days, 21·1% <6 days, 40·7% none; ~0·4% reported no sheltering capacity; respondents with children, pet owners, those with strong community attachment, full-time workers, those aged 50-64 more likely to have a designated meeting place; education and income not predictors	16
	• **Studies involving actual events or published communication materials**	
	Miller (1981). (QN)~62% 'very'/ 'somewhat' prepared to stay away from home >one week	16
	Zwolinski et al. (2012). (QN) 5·3% collected free KI; **voucher non-users reported not having planned for a NPP emergency to a greater extent (60%) than users (25·6%) x2=18·47, p<·0001);** reasons for (pre-incident) uptake of KI: be prepared (57·7%), safety (18%), free (14·1%), recommended (12·8%); reasons for non-use: not knowing about program (36%), 'don't know' (18·7%), didn't receive voucher (12%), 'not interested' (6·7%), felt KI unnecessary (4%)	17

		Risk of bias score
Adherence to recommendations	• **Studies involving hypothetical scenarios**	
	Latré et al. (2018). **(QL)** Acceptance of (pre-incident) recommendations not affected by perceived credibility of actor giving information	19
	• **Studies involving actual events or published communication materials**	
	Miller (1981). (QN) 66% would leave if warned via media of impending nuclear attack, if warning intensified (such as televised Presidential message) 73% would probably/ definitely leave; **fewer (48%) would leave if learned of actual attack occurring (compared with media warning (x2=5·98, df=1 p<·01) or presidential TV warning (x2=9·96,df=1, p<·01)**	17 14
	Prince-Embury (1992ii). (QN) **Perception of radiation risks (β=-0·3, SE=0·04), prior knowledge (β= 0·2, SE=0·02) most influential acceptance predictors of message acceptance (Slovenia: e.g. 'LILW will not cause health consequences'); prior knowledge (β=-0·357, SE=0·042), attitude towards science and technology (β=-0·350, SE=0·116), perception of radiation risks (β=0·264, SE=0·1), living close to NPP (β=0·739, SE=0·242) predicted acceptance of messages (Belgium); differences in message acceptance between respondents living farther from NPP and local population (Slovenia: β= 0·1; Belgium: B=0·7);** confidence in authorities not significant	13 17
	Perry (1981). (QN) **Interaction of specific knowledge and trusting authorities predicted message acceptance in affected population (β =0·029, SE=0·009, p<0·01);** specific knowledge not significant **(joint effect of specific knowledge and disaster potential did predict acceptance in general population (β=·13, SE=0·42, p<0·01); attitude toward science and technology marginally significant effect on acceptance in affected population (those with a more positive attitude less inclined to accept messages (β=-1·077, SE=0·402, p<0·05)); respondents believing NPP accident potentially disastrous accepted messages less than those assuming low disaster potential in general (β=−1·66, SE=0·540, p<0·01) and directly affected (β=·46, SE=0·108, p<0·001) populations;** education and age not significant	19
	Rubin et al. (2012). (QN) 18%-19% would evacuate if given prior notice of incident; 19% would leave location if instructed by Governor/ Mayor (highest level of shelter-in-place adherence), 21% if local fire chief, 24% if 'a top local official' or 'the local emergency manager'	17
	Houts et al. (1980). (Experiment) 86% adhered to instructions to keep both leaflets (94% read both)	

Table B3. Predictors of behaviour immediately following a radiation emergency (significant effects in bold)

		Risk of bias score
Information Seeking	• **Studies involving actual events or published communication materials**	
	Rubin et al. (2012). (QN) Uncertainty (e.g. doubt around exposure) caused emotional symptoms: distress, anxiety, anger, found to predict information seeking behaviour	19
Adherence to recommendations	• **Studies involving hypothetical scenarios**	
	Becker (2004). (QL) Minority groups would ‘start rounding up…family’ in reaction to a nuclear emergency	17
	Oak Ridge (2011). (QL) Respondents found sheltering directives counterintuitive (such as feeling that staying inside was not safe), would likely not follow instructions to shelter-in-place	12
	Bass et al. (2015). (QL) Adherence associated with trust in source, perception of scenario, knowledge of issue, collaboration of information, family-centric needs (women/older people would check safety of children before evacuating)	20
	Rogers et al. (2013). (QL) Receiving leaflet intervention (including information about decontamination) a strong influencer on adherence	17
	Malěsič et al. (2015). (QN) 2/3 expect support measures relating to physical health and safety, anticipated adherence increased in the 32% who expect psychological assistance if sheltering-in-place; non-adherence associated with prioritising collection or checking on children or other family members	15
	Zeigler & Johnson (2010). (QN) **Situational variables related to evacuation: specific instructions to evacuate, disruption of telephone service, proximity to TMI** (effects not reported)	10
	Nasar & Greenberg (1984). (QN) If knowledgeable of school evacuation plans/ children’s location: 55% of parents would ‘definitely’ (37%)/ ‘probably’ (17%) collect children (no significant difference from those who would not collect their children (14% ‘probably’/ 26% ‘definitely’)	14
	Nyaku et al. (2014). (QN) 96% willing to evacuate; 91·8% willing to shelter-in-place; reasons for non-evacuation: lack of transportation/ inconvenience/ expense; reasons for non-sheltering: wishing to reunite with family, preferring to leave quickly, lack of trust in public health officials	12
	• **Studies involving actual events or published communication materials**	
	Cutter & Barnes (1982). (QN) 39% within 5 miles of TMI evacuated (54% did so following advisory that only pregnant women and children evacuate); **significant association between behaviour and behaviour of neighbours (x2=56·83, df=2, p=·000, Goodman and Kruskal Tau=0·159)**; reasons for evacuating: advisory itself (68%; 21% living outside 5 mile radius, 28% had children), fear of harm (46%), confusion (lack of leadership, conflicting information (41%)), peer pressure (9%), anticipating evacuation order/ associated problems (traffic (8%)); reasons for non-evacuation: **social influence (such as neighbours’ behaviour** (effect not reported), little perception of danger, fear of looting, waiting for order, proximity to hazard, age, household size	16
	Miller (1981). (QN) 92·4% ‘very’/‘somewhat’ likely to adhere with evacuation instructions (90·9% in dirty bomb emergency); sources cited as most important in evacuation decision: official announcement (43·3%), news coverage (42·8%), family/ friends (8·5%); ~67% likely to shelter if news coverage is unavailable; 19·5% with no confidence in government preparedness planning very unlikely to follow shelter-in-place advice (~5% with confidence unlikely to adhere to sheltering directive) (x2=55·63 (n=773), p<·001); **78% who perceive high likelihood that attack could harm them/ their family likely to evacuate x2=70·57 (9, n=748), p <·001, effect size γ=·32); 90% in dirty bomb scenario (x2=70·57 (9, n=748), p<·001, effect size γ=·32)**	16
	Houts et al. (1980). (QN) ~60% of households had at least one person self-evacuate during TMI; reasons for evacuation: confused by information (reducing trust in government), situation perceived dangerous (w/ influence of friends/ neighbours: 82%), avoid forced evacuation (68%); reasons for not evacuating: ‘whatever happens is in God’s hands’ (69·6%), waiting for order (61·9%), believing no danger (30%)	12
	Kanda et al. (2013ii). (QN) **Internet users more likely than non-users to evacuate with families to lower radiation areas (Mantel–Haenszel test conducted, p<·01); positive relationship between internet usage and preventative behaviours (internet users: M=2·6, SD=2·1; non-users: M=1·9, SD=1·7; ANCOVA conducted p<·01**)	16
	Kanda et al. (2013iii). (QN) Families with children aged 0-6 (OR=4·8), 7-12 (OR=3·6), 13-19 (OR=2) reported evacuating during Fukushima disaster	16

		Risk of bias score
Adherence to recommendations	• **Studies involving hypothetical scenarios**	
	Williams et al. (2005). (QN) 84·1% would follow instructions to stay at home (15·5% would leave); community attachment predicted increased willingness to shelter at home; 94·2% of over 65's, 69·9% of 18-25s would adhere to sheltering instructions; 28·4% would shelter for 48 hours if knowing family safe (40·6% at work), 60·6% would leave work despite knowing building sheltering arrangements; reasons for leaving: feel safer elsewhere (36·6%), find children (28·4%), find adult family member (24·9%), get food/ water (11·4%); **bringing food, water, supplies directly to confined residents would increase cooperation (85·4% would shelter 48 hours at home, 75·4% at work)**	16
	Pheby & Robinson (1990). (QN) ~50% would evacuate given advisory 'everyone living within 10km should evacuate'; 25% would evacuate given advisory 'those living within 5km should stay indoors'; 34% would evacuate given advisory 'pregnant women and pre-school children within 5km should evacuate, everyone else within 10km should stay indoors'; families closer to NPP most likely to evacuate	11
	Gerber et al. (2006). (QN) 71·5% if no instructions issued would stay at home; if at work 71·2% (maximum scenario: multiple RDDs at 1 mile distance, wind blowing toward participant) to 41·3% (minimum scenario: single RDD at great distance) would remain in place; reasons for non-adherence (w/ 48 hour shelter instruction): to find adult family (29·1%), to find children (22·6%), feel safer elsewhere (11%), to get food/ water (8·4%); 69·5% (minimum scenario), 82·8% (maximum) would shelter 48 hours if told loved ones safe; 89·6% would shelter for >48 hours if food/ water could be delivered (100% in maximum scenario); confidence in community ability to manage attack does not affect behaviour if at home **(significantly correlated with staying at work in minimum scenario)**	11
	Lasker (2004). (QN) 68% would shelter initially, 59% as long as instructed, 20% requiring more information to decide; trust in official pre-incident instructions correlated with anticipated adherence ; of non-adherence group: 33% would leave to find children, 28% for other family members, 22% would feel safer elsewhere, 7% believe they could avoid danger outside, 6% to get meds/food/supplies; increased adherence if able to communicate with loved ones (+14%), if knowing loved ones safe (+12%); anticipated adherence 76% among those confident in workplace preparedness plans	16
	• **Studies involving actual events or published communication materials**	
	Perry (1981). (QN) Reasons for evacuating during TMI emergency: situational danger (91%), confusing information (83%), concerns with forced evacuation (76%), need to protect children (61%); reasons for not evacuating: not being ordered to (62%), conflicting reports (42%), believing no danger existed (38%), believing home to be safe distance away (31%)	12
	Perry (1983). (QN) Reasons for evacuating during TMI: situational danger (30%), conflicting reports (19%), government advisory (14%), concerns w/ forced evacuation (14%); reasons for not evacuating: not ordered to (62%), conflicting reports (42%), believing no danger existed (38%), living safe distance away (31%), fear of looting (24%), having no children (23%), neighbours not having evacuated (16%)	3
	Houts et al. (1980). (QN) 13·4% would ignore evacuation instructions; three-quarters would evacuate in spite of sheltering instructions (particularly if > 3km from NPP)	7
	Prince-Embury (1992ii). (QN) TMI evacuees more likely to have attained high school education, more likely female (69%), more likely parents (92%)	11
	Van Bladel et al. (2000). (QN) Anticipated pre-incident responses to receipt of warning leaflet: self-evacuate if possible (23%), pick up children (30%), accept sheltering recommendations (96%)	15

Table B4. Preferences for information in the event of a radiation incident (significant effects in bold)

		Risk of bias score
Information Seeking	• **Studies involving hypothetical scenarios**	
	Becker (2004). (QL; QN) Sources likely used (during incident): media (TV), radio, internet, national level experts, word of mouth, emergency broadcast system, authorities understanding local situation	17
	Bass et al. (2015). (QL) Young men would want to find out more information (during incident) by seeking out peers	20
	RTAC (2008). (QL) Preferred sources (during incident): media, medical experts	12
	Malěsič et al. (2015). (QN) 52% sought (pre-incident) information from media, 62% from leaflet	15
	Carini (2011). (QN) Majority (effect not reported) would call local agencies/ family/ friends/ local hospital (during incident); 86% would like guidance on emergency countermeasures/ food safety advice	14
	Nyaku et al. (2014). (QN) (during incident) 13·6% would use internet for information, 55·8% television, 18·4% radio	12
	Taylor et al. (2011). (QN) Nuclear emergencies likely to result in demand for phone services; Preferred information sources (during incident) friends/ family (92%), first responders (76%)	18
	Guterbock et al. (2010). (QN) Preferred sources (pre-incident): general internet searching (27·6%), government websites (21·3%), news websites (21·2%), local TV news (25·2%), family (23·6%), friends (20·8%), local radio (21·2%); Preferred sources (during incident): television network news (79·6%), (internet: news/ government websites (48·7%), social media (<2%), healthcare provider or CDC (<2%))	16
	Lasker (2004). (QN) 77% 'moderately'/ 'extremely' interested in learning more about government/ community organisation plans for (pre-incident) RDD response	16
	Bass et al (2016i). (QN) 77·2% would seek health-related information (pre-incident) about prevention, protection, symptoms and treatment, likelihood of further attacks (RDD emergency)	17
	Rogers et al. (2013). (QL) Desired information: factual, protective actions, water/food contamination, actions of authorities (during incident); Zone maps requested (w/ advice/behavioural recommendations)	16
	Williams et al. (2010). (QN) Preferred sources (during incident): local TV news (68·4%), local radio (62·7%), national TV news (49%), internet news (26·4%), internet unspecified (22·3%), internet government site (16%), local newspapers (15·9%), family/ friends (15·6%), local police (9·6%), local fire dept. (5·8%), doctors/ healthcare providers (3·4%)	17
	• **Studies involving actual events or published communication materials**	
	Rubin et al. (2012). (QL) Individuals made requests (during incident) for more information, consistency, clarity, regular updates	19
	Cutter & Barnes (1982). (QN) Some (effect not reported) sought information regarding potential impact before evacuating following advisory (during incident)	16
	Kanda et al. (2013i). (QN) Main information sources (during incident): neighbours, co-workers (effect not reported)	15
	Vyncke et al. (2016). (QN) 93·4% used media for information during Fukushima emergency	17
	Hellier et al. (2014). (Experiment) Reasons for preference of (pre-incident) intervention leaflet over existing NSIL: simpler/easier to understand, more informative, offered pin-up summary, preferred pictures, preferred layout; NSIL preferred for familiarity, preferred layout, preferred pictures	19

		Risk of bias score
Perceived credibility of information source	• **Studies involving hypothetical scenarios**	
	Becker (2004). (QL; QN) Concerns expressed that government will not distribute all information/lack of availability in different languages (pre-incident); recommended actions more credible if proven effective	17
	Bass et al. (2015). (QL) Limited trust in national media (local media preferred), local authorities (president directives preferred) (during incident)	20
	Bass et al. (2016i). (QL) Information presented in media (during incident) viewed with suspicion; positive reaction non-governmental sources; 'Independent scientist' lost credibility as 'chosen by media'	16
	Rogers et al. (2013). (QL) Lack of consistency across messengers (during incident) increased confusion/ anxiety; leaflet recipients rated messages from authorities more credible	17
	RTAC (2008). (QL) 33% rated media as a credible (pre-incident) source of information, 30% first responders, 16% academics/ scientists, 14% government	12
	Bass et al. (2016ii). (QN) (pre-incident) Respondents fell into 3 categories: trust information, not response (32%: most likely to adhere), distrust information and response (18%: least likely to adhere/ prepare), trust local, not global (50%: likely to adhere with sheltering instructions, most likely to have an emergency plan)	19
	Pearce et al. (2013). (QN) **Scientists rated more trustworthy than authorities (t(458)=3·03, p<·05); authorities rated more trustworthy than industry (t(458)=6·554, p<·05);** Authorities/ scientists rated equally competent (t(449) =-·14; p=·150), **industry less competent (t(449)=3·6, p<·01)** (pre-incident)	19
	Nyaku et al. (2014). (QN) 36·5% had most trust in the local public health department, 23%in local news, 11·2% physicians, 11·1% family members (pre-incident)	12
	Guterbock et al. (2010). (QN) Trust in source (pre-incident): president (~42%), homeland security (~22%), GP (~22%), surgeon general (~20%), religious leader (~20%), Governor (~19%), national/local news (~15%)	19
	Williams et al. (2005). (QN) National news most trusted source, followed by GP (pre-incident); least trusted: Mayor/ local religious leaders; medical professionals appearing on television perceived less reliable	16
	Carini (2011). (QN) ~60% reported confidence in official information (during incident) (most likely women/ aged 26-40 years); 30% reported little confidence (most likely aged 41-60 years)	14
	• **Studies involving actual events or published communication materials**	
	Perko et al. (2012). (QN) (Slovenia) Trust in scientific information given by: Government (factor loading principal axis=0·779); agency for radioactive waste (axis=0·591); mayor (axis=0·530); ministry for environment and spatial planning (axis=0·735) (alpha=0·75, N=1200) (pre-incident)	13
	Prince-Embury (1992i). (QN) **Perceived understandability (X=·981, SD=·138),** reliability (X=·818, SD=·387) and relevance (X=·725, SD=·448) (pre-incident) consistent with course presenters giving information in basic terms	17
	Prince-Embury (1992ii). (QN) **Loss of faith in experts predicted by perceived TMI threat (multi R=·70, R^2=·48, p=·000), perceived lack of control (multi R=·57, R^2=·33, p=·000)** (during incident)	15
	Hellier et al. (2014). (Experiment) No significant difference between leaflets for trustworthiness (pre-incident)	17
Reception of information	• **Studies involving hypothetical scenarios**	
	Becker (2004). (QL) Many found information (pre-incident) confusing, unclear (such as not fully understanding the terms shelter-in-place or plume)	17
	Oak Ridge (2011). (QL) A live voice (opposed to a recording) preferred in delivering messages (during incident)	12
	Bass et al. (2016i). (QL) Intervention leaflet length, density and complexity of text, lack of illustrations, accessibility issues for groups with disabilities criticised) (during incident)	16
	Rogers et al. (2013). (QL) (during incident) Official recommendations suggested to go beyond providing facts by offering explanations for public health recommendations (also applied to official advice encouraging return to normal after sheltering and advice encouraging the public to attend a treatment centre	17
	Latré et al. (2018). (QL; QN) **Confidence in knowing what RDD was (intervention group: M=8·76, SD=2·64; control: M=5·44, SD=3·75; t=2·78, df=28, p<·05, 95%CI=·87-5·77), how to respond (intervention: M=8·95, SD=1·5; control: M=6·67, SD=3·61; t=2·49, df=28, p<·05, 95%CI=·4-4·17), ability to carry out instructions (intervention: M=8·8, SD=·62; control: M=7·44, SD=1·94; t=2·87, df=27, p<·05, 95%CI=·386-2·3) in low literacy respondents given literacy aided material (pre-incident)**	18
	• **Studies involving actual events or published communication materials**	
	Hellier et al. (2014). (Experiment) 55·5% read all leaflet information (49·4% reported having understood it all) (pre-incident); 57% preferred trial leaflet to existing leaflet (31%); **trial leaflet found easier to read than NSIL (F(1, 295)=19·347, p<·001, r=27);** trial leaflet found easier to understand (59%) than existing leaflets (24%)	17

Appendix C. Tables for each Theoretical Domain Framework domain (with examples for each construct) mapped from systematic review outcomes

TDF Domain 1: Knowledge			
Knowledge constructs	**Type of construct**	**No. of studies that show this**	**Example**
Knowledge of condition/scientific rationale	Prior knowledge	5	Interaction of specific knowledge and trusting authorities predicted message acceptance
	Adherence	2	83% would shelter 48 hours if told loved ones safe
	Information seeking	2	Some sought information regarding potential impact before evacuating following advisory (during incident)
	Materials	2	Confidence in knowing what RDD was, how to respond, in low literacy respondents given literacy aided material (pre-incident)
	KI non-use	2	Reasons for non-use: not knowing about program
Procedural knowledge	Procedural knowledge	4	Receiving leaflet intervention (including information about decontamination) a strong influencer on adherence
	Perceived front-line preparedness	3	Perceived government or front-line preparedness not significant predictor
	Uncertainty / fatalism	2	Barriers to preparedness: can't plan for unknown
	Method	1	Internet usage predicted knowledge of preventative behaviours
		Total = 23	

TDF Domain 2: Skills			
skills constructs	**Type of construct**	**No. of studies that show this**	**Example**
-	-	0	-

TDF Domain 3: Social / professional role identity			
Social Identity constructs	**Type of construct**	**No. of studies that show this**	**Example**
Social identity	Community attachment	2	Community attachment predicted increased willingness to shelter at home
Group ID	Parental status	13	Non-adherence associated with prioritising collection or checking on children
		2	Respondents with children more likely to have prepared
	Age	5	Older respondents more likely to have emergency supply kit
	Education	3	Information seekers near TMI were more highly educated
		1	TMI evacuees more likely to have attained high school education
	Gender	2	TMI evacuees more likely female
	Pets	1	pet owners more likely prepared
	Employment	1	full-time workers more likely prepared
		Total = 30	

TDF Domain 4: Beliefs about capabilities			
Beliefs about capabilities constructs	**Type of construct**	**No. of studies that show this**	**Example**
Self-efficacy	Coping efficacy	5	Recommended actions more credible if proven effective
Perceived competence	Community preparedness	2	confidence in community ability to manage attack does not affect behaviour if at home
Beliefs	Danger	2	Sheltering directives felt counterintuitive would likely not follow instructions to shelter-in-place
		Total = 9	

TDF Domain 5: Optimism			
Optimism constructs	**Type of construct**	**No. of studies that show this**	**Example**
Pessimism	Pessimism	1	Few preparedness behaviours due to belief nuclear sites are safe/ in emergency there would not be time to evacuate

TDF Domain 6: Beliefs about consequences			
Beliefs about consequences constructs	**Type of construct**	**No. of studies that show this**	**Example**
Outcome expectancies'	Perceived personal impact	7	78% who perceive high likelihood that attack could harm them/ their family likely to evacuate
		2	Reasons for non-evacuation: fear of looting
Attitudes	Perceived seriousness	2	respondents believing NPP accident potentially disastrous accepted messages less
		1	Perceived seriousness a predictor of preparedness
	Risk perception	2	Perception of radiation risks most influential acceptance predictors of message acceptance
Beliefs	Perceived probability	2	Perceived probability a predictor of preparedness
	Fatalism	2	Reason for not evacuating: ‘whatever happens is in God’s hands’
		Total = 18	

TDF Domain 7: Reinforcement			
Reinforcement constructs	**Type of construct**	**No. of studies that show this**	**Example**
Incentives; contingencies	Associated difficulties	1	Reasons for evacuating: anticipating evacuation order/ associated problems (traffic)
	Assistance	1	Anticipated adherence increased in the 32% who expect psychological assistance if sheltering-in-place

TDF Domain 8: Intentions			
Intentions constructs	**Type of construct**	**No. of studies that show this**	**Example**
Intrinsic motivation	Urgency	1	48% would self-evacuate if learned of actual attack occurring
	Notice	1	18%-19% would evacuate if given prior notice of incident

TDF Domain 9: Goals			
Goals constructs	**Type of construct**	**No. of studies that show this**	**Example**
Goals; action planning	Preparedness	1	Reasons for uptake of KI: be prepared

TDF Domain 10: Memory, attention, decision processes			
Memory, attention, decision processes constructs	**Type of construct**	**No. of studies that show this**	**Example**
Cognitive overload/tiredness	Uncertainty	1	Uncertainty (e.g. doubt around exposure) found to predict information seeking behaviour
		7	Reasons for evacuating: confusion (lack of leadership, conflicting information)
Attention control	Instruction	13	Situational variables related to evacuation: specific instructions to evacuate
		2	Many found information (pre-incident) confusing, unclear (such as not fully understanding the terms shelter-in-place or plume)
Decision making	Denial/ unwillingness	1	Denial is a barrier to preparedness
	Opinion of source	10	Attitude toward science and technology marginally significant effect on acceptance in affected population (those with a more positive attitude less inclined to accept messages
		4	Reasons for non-sheltering: lack of trust in public health officials
		Total = 38	

TDF Domain 11: Environmental context and resources			
Environmental context and resources construct	**Type of construct**	**No. of studies that show this**	**Example**
Environmental stressors	Time	1	Barriers to preparedness: lack of time
Resources	Resources	5	Barriers to preparedness: lack of money / resources
		2	Bringing food, water, supplies directly to confined residents would increase cooperation
Person x environment interaction	Geography	5	Urban area residents prepped to lesser extent than rural residents
		1	Living close to NPP predicted acceptance of messages
		Total = 14	

TDF Domain 12: Social influences			
Social influences construct	**Type of construct**	**No. of studies that show this**	**Example**
Social and group pressure	Common opinion	1	Adherence associated with collaboration of information
	Social	1	Significant association between behaviour and behaviour of neighbours
		4	Reasons for non-evacuation: social influence (such as neighbours' behaviour
Support	Social	1	Young men would want to find out more information (during incident) by seeking out peers
		Total = 7	

TDF Domain 13: Emotion			
Emotion construct	**Type of construct**	**No. of studies that show this**	**Example**
Anxiety	Instruction-related	3	Reasons for evacuating TMI emergency: concerns with forced evacuation
Fear	Worry	4	Information seekers near TMI not necessarily those reporting most worry
		8	Reasons for non-evacuation: little perception of danger
		Total = 15	

TDF Domain 14: Behavioural regulation			
Behavioural regulation construct	**Type of construct**	**No. of studies that show this**	**Example**
Direct experience	Personal experience	1	Preparedness plans in respondents who experienced an event that caused them to stay at home or to evacuate

Appendix D. Full nuclear attack scenario variations presented to focus groups and unused nuclear plant leak scenario for PPI group

Scenario: IND detonation in metropolitan area (Urban groups)

It is a weekday, 10am. You are at home, in your kitchen, stood with your back to the window.

Suddenly a brilliant flash of light fills the room. It is so intense that you are forced to squeeze your eyes shut.

When you open them again your vision is severely impaired? All you can see at first is a red-orange blur which gradually gets darker, as if it is the middle of the night.

You are temporarily disoriented but your vision begins to clear after 10-15 seconds and returns almost to normal.

Instinctively you turn towards the window to see what could have caused this flash.

As you take a step towards the window it smashes violently inwards with a boom.

The shockwave knocks you off your feet.

You stand back up and more cautiously this time, stepping over broken glass, you return to the window.

First you hear the noise of car alarms and feel heat from somewhere.

Next you notice a car along the road which is overturned. Then you notice more glass and debris in the streets and surrounding other cars.

You see smoke nearby and some small fires but cannot tell where they are coming from.

Finally, at what you judge to be two to three miles in the distance, you see a large cloud rising quickly into the air.

Scenario: IND detonation in metropolitan area (Rural groups)

It is a weekday, 10am. You are at home, in your kitchen, listening to the radio.

A voice suddenly declares that “reports have come in of a major incident having occurred in London.”

The voice is quiet at first but you hear the words “…eyewitness accounts are of a blinding flash of light and smashed windows.”

The message goes on to describe “overturned cars in the street of London.”

In the background of the radio broadcast you can vaguely make out the sounds of car alarms and people shouting and screaming.

The voice on the radio goes quiet for some time, before finally stating “reports confirm a large mushroom cloud rising above central London. It very much appears now that London has been attacked with a nuclear weapon

Scenario 2: Nuclear Plant Emergency

‘It is a weekday, 10am. You are at home, in your kitchen, listening to local radio.

A voice suddenly declares that ‘in the last few minutes an announcement has been made regarding the current state of the _______ nuclear power plant in ________.’

The voice is unclear but you hear the words ‘…partial meltdown in Unit 2 of the reactor’ and ‘release of undetermined levels of radioactive gases.’

The message goes on to describe ‘…pump malfunctions leading to exposure of the core and melting of the fuel rods.’

The voice on the broadcast advises ‘pregnant women and pre-school children within 5 miles of the reactor to evacuate. Sheltering (staying indoors) is recommended for all others within 10 miles of the plant.’’

Appendix E. Full topic guide annotated with associated TDF domains

Theme (information seeking; source credibility; preparedness activities; anticipated instruction compliance; information recall)	Question	Theoretical Domains Framework (domain)
	What are your initial thoughts on the scenario you have just read? • *What might happen?*	
	What are your thoughts about infrastructure damage? *Prompt: phone lines down, buildings damaged or destroyed.* • How might this damage affect people? *Prompt: Emergency response actions?*	Emotions; environment; beliefs about consequences
information seeking; preparedness activities;	**Are you concerned that you might experience something like this?** If yes, how do you manage that fear? / do you do anything to reduce that fear?	Optimism; Social professional role/identity; Emotions
information seeking; preparedness activities; anticipated instruction compliance	**I'd like to hear your thoughts on immediate responses to such an event happening?** *Prompt: think about self-protection, think about protection of others (Initial explosion; Radiation fallout exposure; Injury by other means)* • Would those be your actions? And why? What if I told you that overloading of the phone network can hinder aid. Would you still try to call people? • What if you were told not to try?	Beliefs about capabilities; Memory, attention, decision processes; Skills; Goals; behavioural regulation
anticipated instruction compliance	**If the scenario were to occur, how likely would you be to follow instructions to evacuate?** • Why is that? Is there a difference between those with/without families/dependents? • Why is that? What if I told you that explosion damage will not extend more than 3 to 5 miles, but radioactive material in the air will travel further. Knowing this would it change your intentions to follow instructions? o If no, then why? In the Fukushima Nuclear Power Plant accident some who evacuated against advice were unnecessarily exposed and sadly died. Knowing this would it change your intentions to follow instructions? o If no, then why? What if I told you that evacuation may be chaotic? Evacuating later would likely be easier (such as regarding the amount of traffic on the roads). Knowing this would it change your intentions to follow instructions? o If no, then why?	Social influence; behavioural regulation; intentions;

	What if I told you that dose is directly proportional to exposure time. Knowing this would it change your intentions to follow instructions? o If no, then why? Results of recent tests indicate that a modern urban environment can greatly reduce effects of a nuclear detonation. For example, burns from the heat of the initial explosion can be reduced by buildings blocking it. Knowing this would it change your intentions to follow instructions? o If no, then why? For those who say no: What if I told you this was conducted by scientists / government / nuclear experts	
anticipated instruction compliance	**For those who would evacuate: what if the instruction was to shelter-in-place? How likely would you be to follow this instruction?** • Why is that? Is there a difference between those with/without families/dependents? • Why is that? What if I told you that the most dangerous radiation levels will decrease significantly in the first 24 hours. Knowing this would it change your intentions to follow instructions? o If no, then why? What if I told you that food in sealed containers and any unspoiled food in your refrigerator or freezer are safe to eat and tap water is still drinkable for the entire time you would need to remain indoors. Medicine in sealed containers is also safe. Knowing this would it change your intentions to follow instructions? o If no, then why? What if I told you that schools, hospitals, and nursing homes have emergency plans in place to protect people at the facility in the event of a nuclear explosion. Knowing this would it change your intentions to follow instructions? o If no, then why? Ingestion of stable iodine saturates the thyroid stopping radioactive iodine from being absorbed and accumulated in the thyroid. Knowing this would it change your intentions to follow instructions to use it? o If no, then why? Would you give KI to your families/dependents if such an event occurred? What if in the aforementioned scenario you were at work? Would this change your intentions to follow instructions? o If no, then why? What if you were out in the street when it occurred?	Social influence; behavioural regulation; intentions
	What if this scenario was a release of radiation from Hinkley Point instead? Would anything be different?	

	• Why / Why not?	
Source credibility; information recall; preparedness activities; anticipated instruction compliance	**How could the government get people to engage with information about protective actions to take in radiation emergencies?** *Prompt: what sources are suitable as methods of also disseminating such emergency information?* • Is this different for other types of emergencies such as flooding or fire? • Why would this be the case?	Social professional role/identity
information seeking; source credibility; information recall	**Do any methods for receiving information have benefits over others in terms of warning of radiation risks?** • What about in terms of providing education regarding protective actions **before or immediately after** a radiation incident? • Why might this be the case?	Reinforcement
Information recall	**What might help people to recall this information (given prior to incident) if needed?**	Memory, attention, decision processes
source credibility; preparedness activities; anticipated instruction compliance	**Are there any sources of information who could communicate regarding an emergency of this nature who are more trustworthy than others?** • Why is this the case? And, what would you base your trust on? *Prompt: Accuracy of the information they give, transparency/giving all information there is, bias or prejudice in delivering information, timing of message (i.e. during peacetime or when it happens) etc?* o Why is this the case?	Social influences; reinforcement
information seeking; source credibility; preparedness activities; anticipated instruction compliance	**What would you do if you were to receive such information via your favoured information sources? (i.e. TV, internet, newspaper)?** • Why might this be the case?	Environment; behavioural regulation; intentions
Information seeking; preparedness activities	What do you think you would need to know prior to being alerted of this to help you protect yourself better? *Prompt: decision making regarding protective actions, factual information, where did the attack come from, who is/will be affected* • Why would you need this information?	Beliefs about capabilities; Knowledge; Memory, attention, decision processes
	Is there anything that you feel you would / wouldn't want to know? • Before • Immediately after *Prompt: who carried out the attack, factual information*	
source credibility; anticipated instruction compliance	• What might encourage you to accept advice or information regarding protective radiation preparedness or response actions? • Why might this be the case?	Reinforcement; social influence; behavioural regulation; intentions

	• What would be the most important influence if you were to receive a number of messages? (this could be one particular source, or simply consistency between some, wording, pictures, gut feeling, friends/family follow it etc)	
source credibility; preparedness activities; anticipated instruction compliance	**Would the timing of the instructions make a difference to how it is received?** *Prompt: such as if it requires following* ***proactive instructions****? I.e. pre-event information* *Prompt: such as if it requires following* ***reactive instructions****? i.e. emergency broadcast after the event* • What if it was an emergency broadcast that repeated instructions you had received pre-event?	intentions
source credibility; anticipated instruction compliance; information recall	**Are there any other potential barriers to acceptance of advice or information regarding protective radiation preparedness or response actions not already discussed?** • Why might this be the case?	Reinforcement; social influence; behavioural regulation; intentions
	To be asked within the group:	
	Are there any pieces of radiation related information that I have given during the course of this focus group that has particularly stuck with you? / That you feel is important for people to know?	

Appendix F: Focus group information, consent and demographic data forms

INFORMATION SHEET FOR PARTICIPANTS
Version 2b – **03/04/2017**

KCL Ethics Reference: HR-16/17-4118

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Developing evidence-based communication strategies to promote protective behaviours in nuclear incidents – Focus Group Study

I would like to invite you to take part in this focus group which will make up part of my PhD research project. Please be assured that your decision to participate is entirely up to you: choosing not to take part will not disadvantage you in any way. Before deciding whether to give your consent for this research, please take some time to read the following information regarding its purpose. This will allow you to understand your potential role in taking part. If you wish to discuss this further, please use the contact details at the end of this form.

What is the purpose of the study?

Previous research has found that members of the public often fail to engage in information which explains protective actions people can take in the event of a potentially catastrophic nuclear incident. This may be because of fatalism, the perceived low likelihood of nuclear incidents, anxiety and subsequent avoidance, and suggested actions being seen as ineffective. It is not clear what official communicators should do about this. In particular, we do not know what the preferred sources of pre-incident information sources are or what the preferred content would be.

Through this research I hope to help improve the way emergency responders communicate with the public about preparedness and response to nuclear and other radiation incidents that have the potential to cause harm to public health.

I aim to achieve this by understanding what people know and think about nuclear terrorism and other radiation-type incidents and by identifying what encourages people to engage with pre-incident information about nuclear terrorism.

What are the implications of conducting the study?

There is increasing focus within public health on enabling people to take control of their own health and wellbeing. Practically, providing members of the public with the knowledge they need to take appropriate actions during an incident involving the release of a nuclear agent will enable them to take actions to protect themselves and others, potentially resulting in lives saved.

Why have I been invited to take part?

You have been invited to take part because you are a member of the general public living close to a nuclear reactor, or living within a major city. Only people aged 18 or over can take part. It is also assumed that you have no prior knowledge or training in preparation for, or response to a potentially health threatening incident involving radiation.

Members of a profession who may have received training specific to radiation incidents in terms of preparedness and response, including but not limited to military personnel, emergency first-responders and medical staff are excluded from this study.

Do I have to take part?

No. Your participation in this focus group study is entirely voluntary. Having read this information sheet you should make an informed decision as to whether you wish to take part or not. Only once you have read this information sheet and had any further questions you might have clarified using the contact information at the bottom of this page should you make your decision.

What will happen to me if I take part?

If you decide to take part in this study, you will first be asked to sign a consent form. You will be able to keep this information sheet and I will keep the consent form. You will then be invited to take part in a focus group within your local area. You will attend 1 group which will consist of between 5 to 7 other people, each of whom has received the same information as you. Focus groups will last approximately 2 hours. You will be provided with a scenario about a hypothetical nuclear incident to prompt discussion in which you will be requested to discuss your thoughts on what information you might want before and during an incident of this nature, potential ways you would wish to be provided with this information, and any facilitators or barriers to engagement with this information that you foresee.

You are free to withdraw from this study at any time and without giving any reason. You can do this in person by informing the researcher (for example, during the focus group) or a contact telephone number, e-mail and postal address of two members of the research team will be provided should you wish to make contact to withdraw consent after completion of the focus group. Your data will not be included in this study should you withdraw consent at any point up to 1st November 2017. Beyond this point analysis will have begun. Please note that, although we will make our best efforts to withdraw your data if you request it, the nature of this research means it may not always be possible. For example, if withdrawing your data makes it impossible for us to use data from another participant you are talking to during the focus group.

What are the possible benefits of taking part?

Your participation in this study will help shape future research into public communication regarding preparation and response to incidents involving the release of potentially health threatening radiation. Development of effective communication and messaging strategies will not only protect health and potentially save lives, but will also reduce the cost and burden on the NHS of those experiencing negative health effects not directly attributed to radiation, such as stress and anxiety.

As a thank you for taking part, we will pay you £40 at the end of the focus group. We will also send you a copy for the final report.

Will my taking part be kept confidential?

What is said in the focus group is regarded as strictly confidential. Focus group sessions will be audio recorded for later transcription and analysis. The UK Data Protection Act 1998 will apply to all information gathered within the focus group. Information will be held on password-locked computer files and locked in cabinets within King's College London, and will only be accessible by members of the research team. Participant details will be kept on file, however. This is done in case we need to contact you in the future regarding other research that you might be interested in taking part in. This information will be anonymised for storage and kept in an encrypted file which can be de-anonymised, but only by members of the research team.

All data for analysis will be anonymised. In reporting on the research findings, I will not reveal the names of any participants or the organisation where you work. At all times there will be no possibility of you as individuals being linked with the data.

How is the project being funded?

This project is part of a three-year PhD funded by Public Health England and undertaken through King's College London. This project has been approved by the King's College London Research Ethics Committee.

What will happen to the results of the study?

Results of this study will be summarised into a report of the main findings which will be sent to you and disseminated through publication and conferences within the UK.

Who should I contact for further information?

If you have any questions or require more information about this study, please contact me using the following contact details:

Louis Gauntlett
Department of Psychological Medicine
King's College London
Weston Education Centre
c/o 125 Cold Harbour Lane
London
SE5 9NU

louisgauntlett@kcl.ac.uk
Tel: 020 7848 5684

What if I have further questions, or if something goes wrong?

If this study has harmed you in any way or if you wish to make a complaint about the conduct of the study you can contact King's College London using the details below for further advice and information:

Dr James Rubin
Senior Lecturer in the Psychology of Emerging Health Risks & Assistant Director, NIHR Health Protection Research Unit in Emergency Preparedness and Response at King's College London

Department of Psychological Medicine
King's College London
Weston Education Centre
c/o 125 Cold Harbour Lane
London
SE5 9NU

Tel: 020 7848 5684

Thank you for reading this information sheet and for considering taking part in this research.

CONSENT FORM FOR PARTICIPANTS IN RESEARCH STUDIES

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: Developing evidence-based risk and crisis communication strategies to promote protective health behaviours in nuclear incidents – Focus Group

King's College Research Ethics Committee Ref: HR-16/17-4118

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

I confirm that I understand that by ticking/initialling each box I am consenting to this element of the study. I understand that it will be assumed that unticked/initialled boxes mean that I DO NOT consent to that part of the study. I understand that by not giving consent for any one element I may be deemed ineligible for the study.

Please tick or initial

☐

Please tick or initial

1. I confirm that I have read and understood the information sheet dated 03/04/2017, version 2b for the above study. I have had the opportunity to consider the information and asked questions which have been answered satisfactorily. ☐

2. I understand that I will be able to request that my data be withdrawn at any time up to 1st November 2017. I understand that it may not always be possible for my data to be withdrawn. ☐

3. I consent to the processing of my personal information for the purposes explained to me. I understand that such information will be handled in accordance with the terms of the UK Data Protection Act 1998. ☐

4. I understand that my information may be subject to review by responsible individuals from the College for monitoring and audit purposes. ☐

5. I acknowledge that as with all focus groups there will be other people in the room, therefore confidentiality cannot be guaranteed ☐

6. I understand that confidentiality and anonymity will be maintained wherever possible and it will not be possible to identify me in any publications ☐

7. I agree to be contacted in the future by King's College London ☐

researchers who would like to invite me to participate in follow up studies to this project, or in future studies of a similar nature.

8. I agree that the research team may use my data for future research and understand that any such use of identifiable data would be reviewed and approved by a research ethics committee. (In such cases, as with this project, data would/would not be identifiable in any report). ☐

9. I understand that the information I have submitted will be published as a report and I wish to receive a copy of it. ☐

10. I consent to my interview being audio recorded. ☐

11. I understand that I must not take part if I fall under the exclusion criteria as detailed in the information sheet and explained to me by the researcher. ☐

12. I agree to maintain the confidentiality of focus group discussions outside of the group ☐

Name of Participant	**Date**	**Signature**
Name of Researcher	**Date**	**Signature**

Focus group demographic data collection sheet

Date / Time____

Title of Focus Group: **Developing evidence-based communication strategies to promote protective behaviours in nuclear incidents – Focus Group Study**

KCL Ethics Reference: HR-16/17-4118

I would be grateful if you could complete the following demographic data collection sheet. This information will be used for the purpose of data analysis and information will not be used to identify you in any way.

What is your gender?

☐ Female ☐ Male ☐ Non-binary/ third gender

☐ Prefer to self-describe _________________ ☐ Prefer not to say

What is your age?

☐ 18-24 ☐ 25-44 ☐ 45-64 ☐ 65-74 ☐ 75+ ☐ Prefer not to say

What is your current employment status?

☐ Full-time employment ☐ Part-time employment ☐ Student ☐ Retired

☐ Employed in voluntary role ☐ Not currently in employment ☐ Prefer not to say

What race/ethnicity best describes you? ☐ Prefer not to say

White

☐ English / Welsh / Scottish / N. Irish / British ☐ Irish ☐ Gypsy / Irish Traveller

☐ Any other White background, please describe___________________________

Mixed / Multiple ethnic groups

☐ White and Black Caribbean ☐ White and Black African ☐ White and Asian

☐ Any other Mixed / Multiple ethnic background, please describe____________________________

Asian / Asian British

☐ Indian ☐ Pakistani ☐ Bangladeshi ☐ Chinese

☐ Any other Asian background, please describe____________________________

Black /African / Caribbean / Black British

☐ African ☐ Caribbean ☐ Any other Black /African / Caribbean background, please describe____________________________

Other ethnic group

☐ Arab ☐ Any other ethnic group, please describe_______________________

What is your highest level of education completed?

☐ Completed school ☐ College level qualification ☐ Degree level qualification

☐ Higher than degree level (e.g. masters, PhD) ☐ Did not attend school

☐ Prefer not to say

What is your marital status?

☐ Married ☐ Unmarried, cohabiting ☐ Same-sex civil partnership ☐ Divorced

☐ Separated ☐ Widowed ☐ Single ☐ Prefer not to say

Do you have dependent children?

☐ Yes ☐ No ☐ Prefer not to say

If yes, do your children live with you?

☐ Yes ☐ No ☐ 1 or more of my children live with me

If yes, are your children school-aged?

☐ Yes ☐ No ☐ 1 or more of my children are school aged

Many thanks.

Appendix G. Focus Groups: list of online recruitment resources and advert text

- Gumtree.com
- Facebook Community Groups:
  - *Bridgwater Matters*
  - *Wilstock and Stockmoor Community 'Uncut'*
  - *Minehead Conversation Group*
  - *Fitzhead Village*
  - *Taunton Somerset UK News and Events*
  - *Tower Hamlets Mums*
  - *Love Barnet*
  - *Healthwatch Lewisham*
  - *Community Southwark*
- Callforparticipants.com

Advert text

Advertisement for use for recruitment of volunteers for study ref: HR-16/17-4118, approved by the Psychiatry, Nursing and Midwifery Research Ethics Subcommittee, King's College London. This project contributes to the College's role in conducting research, and teaching research methods. You are under no obligation to reply to this email, however if you choose to, participation in this research is voluntary and you may withdraw at any time.

Participants wanted for the study: **Developing evidence-based communication strategies to promote protective behaviours in nuclear incidents – Focus Group Study**

Despite the potentially catastrophic nature of nuclear and radiological events, there are actions which members of the public can take in order to reduce the risk to themselves and others.

This study aims to examine:

- What information people might want to best protect themselves and others in preparation of deliberate radiation release or accidental nuclear reactor meltdown
- What information people might want to best protect themselves and others in the immediate aftermath of deliberate radiation release or accidental nuclear reactor meltdown
- How people would wish to receive information on protective measures before and after deliberate radiation release or accidental nuclear reactor meltdown

Participants must be over the age of 18, living in London / the vicinity of Hinkley Point, and cannot be working in the healthcare service, emergency response or the military. If selected to take part you will be asked to take part in one focus group lasting 2 hours and consisting of 5 to 7 other people. All participants will receive £40 for their participation.

If you have any queries regarding this research, or wish to register your interest in taking part, please contact: Louis Gauntlett louis.gauntlett@kcl.ac.uk / Tel: 020 7848 5684

Appendix H. Framework matrix constructed at the data abstraction stage of focus group analysis

	DESCRIPTIVE THEMES (w/ codes)				
	1. Preparatory knowledge and activities (6)	pre-existing (radiation) knowledge (3e)	**2. Response to scenario(s)** recall of (1a) / comparison with (1b) previous disasters	actions / behaviours (1f)	emotional response (1g)
Rural groups	pre-incident source source during own prep actions prep of authorities	belief authority preparedness uncertainty knowledge of protective actions fictionalised events	recall / experience of non-nuclear event expectations based on non-nuclear events recall of nuclear events other direct experiences NPP safety Comparison of nuclear events + scenario comparison between scenarios realism effect of perceived increased incidence of terror	sheltering Evacuation other responses (unmeasured) anticipated action of others	fatalism denial / dissociation fear perceived ability to act
Urban groups	pre-incident source source during own prep actions prep of authorities	Belief uncertainty knowledge of protective actions fictionalised accounts	Recall / experience of non-nuclear events expectations based on non-nuclear events recall of nuclear events other direct experiences Comparison of nuclear events + scenario comparison to fictional account realism effect of perceived increased incidence of terror	Sheltering Evacuation other responses (measured) other responses (unmeasured) anticipated action of others	fatalism denial / dissociation fear perceived ability to act

	assumptions (1c)	effect of location on reaction (1e)	information seeking (1f / 2a - 2c)	expectations of info (during event) (3f)	are pre-incident comms wanted? (2J) / why / why not be prepared? (6d / 7)
Rural groups	Perceived likelihood prior warning / expected attack past protections lessons learned emergency response	uncertainty indirect effects risk perception protective factors	info seeking actively contact expect info from why? - collaboration why? Gauge severity /spread / scale why? Advice on actions actions of authorities event method	imminent threat in the event	NO YES
Urban groups	Perceived likelihood prior warning / expected attack emergency response	uncertainty indirect effects risk perception protective factors	info seeking expect info from actively contact why? - collaboration why? Gauge severity /spread / scale why? Advice on actions action related actions of authorities event method	in the event	NO YES

	3. Pre-incident comms (2d-2i) comparison to past info campaigns (1ba)	information / content (2g) / how to present (2i)	sources (2f)	credibility of sources (4a - 4f)	preferred source (3a)	method(2d)
Rural groups	comparison w/ other nuclear comms comparison w/ non-nuclear campaigns (nuclear vs. non-nuclear) comparison w/ non-nuclear campaigns (effect) comparison w/ non-nuclear campaigns (content) comparison w/ non-nuclear campaigns (necessity) comparison w/ non-nuclear campaigns (method) comparison w/ non-nuclear campaigns (source)	what info? / content: actions to take what info? / content: Tablets what info? / content: NPP related what info? / content: event what info? / content: other how to present how to present info: content(specific) how to present info: content (general) how to present info: distribution	source: Government source: Nuclear Other sources	trust credibility of Gov credibility - nuclear industry / authority credibility - national media source credibility - internet / social media credibility - emergency services / military credibility - medical / scientific source specific	Gov Nuclear media other sources	method: leaflet / letter method: media method: internet method: social media other methods
Urban groups	comparison w/ other nuclear comms comparison w/ non-nuclear campaigns (nuclear vs. non-nuclear) comparison w/ non-nuclear campaigns (effect) comparison w/ non-nuclear campaigns (necessity) comparison w/ non-nuclear campaigns (content) comparison w/ non-nuclear campaigns (method) comparison w/ non-nuclear campaigns (source)	what info? / content: actions to take what info? / content: tablets what info? / content: event what info? / content: other info how to present how to present info: content(specific) how to present info: content (general) how to present info: distribution	source: Government source: Nuclear Other sources	trust credibility of Gov credibility - national media source credibility - local media source credibility - internet / social media credibility -emergency services / military credibility - medical / scientific source specific	Gov media other sources	method: leaflet / letter method: media method: internet method: social media other methods

	expectations (pre-info) (3f)	info recall / understanding (1a / 3b - 3c)	what would be the effect of pre-incident nuclear comms? (2h)	**4. Anticipated adherence (1f / 5a - 5c)**	willingness to follow advice (3d)
Rural groups	during peacetime	recall of information campaigns (nuclear) recall of information campaigns (non-nuclear) recall of info misc (understanding)	effects of pre-event info: intention to adhere effects of pre-event info: emotional response effects of pre-event info: further information seeking effects of pre-event info: threat / risk perception effects of pre-event info: Other	sheltering adherence (attack specific) sheltering adherence (HP / NPP specific) sheltering adherence (general) why? / why not? - sheltering evac adherence (HP / NPP specific) evac adherence (general) why? / why not? - evac why? / why not? - other	tablets yes actions in the event engagement with info prep actions
Urban groups	during peacetime	recall of information campaigns (nuclear) recall of information campaigns (non-nuclear) recall of info misc (understanding)	effects of pre-event info: intention to adhere effects of pre-event info: emotional response effects of pre-event info: further information seeking effects of pre-event info: threat / risk perception effects of pre-event info: Other	sheltering adherence (attack specific) sheltering adherence (general) why? / why not? - sheltering evac adherence (attack specific) evac adherence (general) why? / why not? - evac why? / why not? - other	tablets yes engagement with info actions in the event prep actions

Appendix I. Full Hawai'i survey items

Public Responses to the Ballistic Missile Alert of January 2018 – A survey study - Ward Research

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Start of Block: Information Sheet for Participants

Aloha!

Welcome to the survey: Public Responses to the Ballistic Missile Alert of January 2018

Before you decide whether you want to take part, please read the information below. Click the forward arrow at the bottom to move to the next page where you will be asked to consent to participation in this research.

Information for participants

My name is Louis Gauntlett and I would like to invite you to take part in this original research project. You should take part only if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important that you understand why the research is being done and what it involves. Please take time to read the following information carefully and discuss it with others if you wish. Ask us to provide information on anything that is not clear or let us know if you would like more information. This study has been approved by the King's College London Research Ethics Review Committee.

What is the purpose of this research?

The Hawai'i alert was probably the first activation of a credible warning system alerting a population to a possible nuclear attack. This research is intended to find out what people did when they received this alert, and why they behaved in different ways, may help us to design better ways of providing emergency alerts in the future.

Who is conducting and funding the research?

The research is being conducted by a joint team from King's College London, Public Health England and The University of Hawai'i at Mānoa. This research makes up part of a King's College London PhD project, funded as part of the NIHR Health Protection Research Unit in Emergency Preparedness and Response at King's College London, a partnership with Public Health England, which is the Government agency in England in charge of protecting the public's health during emergencies.

Who is being asked to take part?

We are interested in hearing from members of the public who received a warning that a ballistic missile was approaching Hawai'i on January 13th 2018 by any means including mobile phone, radio and word of mouth. If you are in this group and are 18 years of age or older, you are eligible to take part in the study.

What will happen if I take part?

If you would like to take part, we will ask you to fill in an on-line questionnaire. The questionnaire takes about 15 minutes to complete and contains questions about how you heard about the warning, what actions (if any) you took, and what if any additional information you would have wanted. At the end of the questionnaire we will ask you to tell us if you would also be interested in taking part in a second study we are conducting. The second study is more detailed, and involves talking to a researcher in person or on the phone about how you reacted to the message.

What are the possible benefits of taking part?

You will be credited by Ward Research for completing this survey. In addition, we hope that our results will help us understand how best to communicate with people in the event of a major disaster such as a nuclear attack. We hope this will never happen, but if it does, communicating effectively with people may help them understand what protective actions to take and may help to save lives. If you choose to take part in the second part of this study and are selected for the interview phase you will receive a $10 Amazon voucher.

Confidentiality – who will know I am taking part in the study?

Your responses will be completely confidential. The responses you provide will be used within the research study and will be stored on a password protected drive for the duration of this project. At the end of this survey you will be given the opportunity for further participation in this study through a 1:1 interview (face-to-face or via telephone). If you wish to take part you be asked to leave your name and contact information. Nobody from outside the research team will be allowed access this or any other information that might identify you.

What will happen to the results of the study?

We will send a copy of our final report with a summary to everyone who requests it. We also hope to publish our results (without any personally identifiable information) in a peer-reviewed journal.

Do I have to take part?

No. Your participation in this project is completely voluntary. You may stop participating at any time without giving any reason. If you stop being in the study, there will be no penalty or loss to you.

You can do this by closing the link of the survey prior to starting or completing it. Data from unfinished surveys (i.e. those closed prior to completion) will not be used in the final analysis and will be discarded. Each page of the survey will include a 'next' button to move to the next question. Next buttons will only become live once a response is given to the question, by responding to each question and clicking 'finish' at the last page indicates consent for responses to be used in analysis.

If you decide to take part, you will still be free to withdraw your data within two weeks of submitting the survey, without giving a reason.

What happens now?

If this study has harmed you in any way or if you wish to make a complaint about the conduct of the study you can contact King's College London using the details below for further advice and information:

Dr James Rubin gideon.rubin@kcl.ac.uk on +44 020 7848 5684. Address: Department of Psychological Medicine, King’s College London, Weston Education Centre, c/o 125 Cold Harbour Lane, London, SE5 9NU

Please visit http://go.hawaii.edu/jRd for more information on your rights as a research participant.

Mahalo!

Page Break

End of Block: Information Sheet for Participants

Start of Block: Individual identifier

ID Please enter the individual identifier sent to you by Ward Research in the space below. Failure to do so will mean you are unable to be credited by Ward Research.

Please note that this identifier WILL NOT be associated with your responses to this survey.

____

End of Block: Individual identifier

Start of Block: Consent to take part

If you think you might like to help with this important study and are willing to proceed, please read and check each statement below and select a response from the drop down box below.
I confirm that I am 18 years of age or older

I confirm that I was in Hawai'i on 13th January 2018

I understand that my responses will be stored securely for the duration of this research study

I understand that my information may be subject to review by responsible individuals from the College for monitoring and audit purposes

I understand that participation in this study is voluntary and that I am free to withdraw at any time by closing the document

I understand that I am free to request deletion of my responses within two weeks of submitting the survey

I confirm that I have read and understood the information above and I agree to take part in this study

▼ I consent to all of the above items (1) ... I DO NOT consent to all of the above items (2)

Skip To: End of Survey If you think you might like to help with this important study and are willing to proceed, please... != I consent to all of the above items

End of Block: Consent to take part

Start of Block: About you

Q1 **This first section is designed to find out about you.** I am (select one)

- Male (1)
- Female (2)
- Non-binary gender (3)
- Prefer not to say (4)

End of Block: About you

Start of Block: About you

Q2 On **January 13th 2018** I was (select one)

- Between 18 – 29 years old (1)
- Between 30 – 39 years old (2)
- Between 40 – 49 years old (3)
- Between 50 – 59 years old (4)
- Between 60 – 69 years old (5)
- 70 years or above (6)
- Prefer not to say (7)

End of Block: About you

Start of Block: About you

Q3 On **January 13th 2018** did you have at least one dependent child? (select all that apply)

- No (1)
- I had a dependent child / children aged under 18 who was living with me (2)
- I had a dependent child / children aged over 18 who was living with me (3)
- I had a dependent child / children under 18 but they did not live with me (4)

End of Block: About you

Start of Block: About you

Q4 How would you describe your ethnicity? (select all that apply)

- American Indian or Alaska Native (1)
- Asian (2)
- Black or African American (3)
- Hispanic or Latino (4)
- Native Hawaiian or Other Pacific Islander (5)
- White (6)
- Other (please specify) (7) ____
- Prefer not to say (8)

End of Block: About you

Start of Block: About you

Q5 Which of the following best describes your employment status on **January 13th 2018** I was.... (select one)

- Employed, working 40 hours or more per week (1)
- Employed, working 1-39 hours per week (2)
- Not employed, looking for work (3)
- Not employed, not looking for work (4)
- Retired (5)
- Disabled, not able to work (6)

End of Block: About you

Start of Block: About you

Q6 What is the highest level of school you have completed or the highest degree you have received? (Select one)

- Less than high school degree (1)
- High school degree or equivalent (e.g. GED) (2)
- Some college but no degree (3)
- Associate degree (4)
- Bachelor degree (5)
- Graduate degree (6)
- Prefer not to say (7)

End of Block: About you

Start of Block: Immediate response

Q7.1 **This section aims to understand immediate responses of the public to receiving the ballistic missile warning on January 13th 2018.** How were you **first** made aware of the ballistic missile warning? (select one)

- Official warning message from the Hawai'i Emergency Management Agency (HI-EMA) via SMS / text message to your cell phone (1)
- Public warning siren sounding (2)
- National news (Television / radio) (3)
- Local news (Television / radio) (4)
- Word of mouth (informed by friend / family / neighbour in person) (5)
- Other (please specify) (7) ____
- I wasn't made aware until I saw the second message informing me that it had been a false alarm / after the false alarm message (8)

Skip To: End of Block If This section aims to understand immediate responses of the public to receiving the ballistic miss... = I wasn't made aware until I saw the second message informing me that it had been a false alarm / after the false alarm message

Q7.2 Where were you upon first receiving the warning? (Select one)

- At home, indoors (1)
- At work, college, university or school (indoors) (2)
- Working outdoors (3)
- In another public area (outdoors) e.g. on the street (4)
- In another public area (indoors) e..g. in a cafe (5)

End of Block: Immediate response

Start of Block: Immediate response

Q8.1 Upon first hearing the original warning, did you believe that it had been sent by HI-EMA?

- Yes – I believed that the warning came from HI-EMA (1)
- No – I believed the warning to be from a source other than HI-EMA (2)
- No – I believed the warning to be a hoax (3)
- N/A - I did not hear until after it was known to be a false alarm (4)

Skip To: Q8.3 If Upon first hearing the original warning, did you believe that it had been sent by HI-EMA? = Yes – I believed that the warning came from HI-EMA

Skip To: End of Block If Upon first hearing the original warning, did you believe that it had been sent by HI-EMA? = N/A - I did not hear until after it was known to be a false alarm

Q8.2
Why did you not believe the warning to be genuine or from HI-EMA? (enter text)

____

Q8.3 Did you believe that an attack was imminent?

- Yes – I believed that an attack was imminent (1)
- No – I believed the warning to be a hoax or a mistake or that it would come to nothing (2)

End of Block: Immediate response

Start of Block: Immediate response

Q9.1 Which of the following best describes your immediate response to first hearing the warning? (select all that apply)

- Took no action/carried on with what I was doing (1)
- Sought immediate shelter (2)
- Made efforts to verify that the information was correct / the warning was genuine (3)
- Made efforts to find out protective actions I could take (4)
- Immediately initiated a pre-arranged plan (5)
- Left home/the place I was at to seek out friends or family (6)
- Got in contact with / tried to get in contact with friends / family using social media or by phone (7)
- Other (please write in the box below) (8)
____

Skip To: Q9.3 If Which of the following best describes your immediate response to first hearing the warning? (sele... != Took no action/carried on with what I was doing

Q9.2 Why did you take no action/carry on with what you had been doing? (enter text)

____

Skip To: Q9.4 If Why did you take no action/carry on with what you had been doing? (enter text) Is Not Empty

Q9.3 Why did you take the action you did upon receiving the ballistic missile warning? (select all that apply)

- I felt prepared / knowledgeable as to what actions I should take (1)
- I felt unprepared / lacked knowledge as to what actions I should take (2)
- I wished to verify that the information received was accurate (3)
- I wanted to protect my family (4)
- I wanted to be with family / friends (5)
- I wanted to help others (strangers) who may have been hurt (6)
- My family / friends and I had a pre-arranged meeting place for such an emergency (7)
- I did what the warning advised me to do (regardless of whether I felt it the safest action or not) (8)
- I thought my actions would protect me (9)
- Other reasons (please specify) (10) ____

Q9.4 Please select any ways in which you attempted to find out information as to how to protect self / others following receipt of the warning (select all that apply)

- N/A (I did not seek information about protective actions when I received the warning) (1)
- Searched online (web search) (2)
- Checked on social media (3)
- Contacted HI-EMA (4)
- Contacted friends / family (5)
- Contacted another agency / authority (please type enter of agency) (6) ____
- Other (please specify) (7) ____

End of Block: Immediate response

Start of Block: Preparedness

Q10.1 **This section will ask you about your emergency preparedness**

	Which from the list below did you have on January 13th 2018?			If yes, please state why you have this item.			
	Yes (1)	No (2)	N/A (3)	Nuclear attack (1)	A different type of emergency (e.g. flooding) (2)	No specific emergency (general preparedness) (3)	Not for emergency preparedness reasons (4)
A spare supply of medication (1)	•	•	•	•	•	•	•
A battery powered radio (4)	•	•	•	•	•	•	•
A 14 day supply of food/water (5)	•	•	•	•	•	•	•
Walkie-talkies (6)	•	•	•	•	•	•	•
A flashlight (and extra batteries) (7)	•	•	•	•	•	•	•
A first aid kit (8)	•	•	•	•	•	•	•
A stored bag with cash and important documents (9)	•	•	•	•	•	•	•
Other preparedness item(s) (please specify) (11)	•	•	•	•	•	•	•

Q10.2 Prior to January 13th 2018, had you received information regarding general disaster preparedness? (select one)

- A great deal of information (1)
- Some information (2)
- A little information (3)
- No information (4)

Q10.3 Prior to January 13th 2018, had you received information regarding preparedness and / or protective actions you could take before and in the event specifically of a nuclear attack? (select one)

- A great deal of information (1)
- Some information (2)
- A little information (3)
- No information (4)

Skip To: Q10.7 If Prior to January 13th 2018, had you received information regarding preparedness and / or protecti... = No information

Q10.4 Where did that information come from? (select all that apply)

- Local authorities (e.g. council; mayor's office) (4)
- Social media (5)
- Local news media (6)
- National news media (7)
- Friends / family (8)
- National government sources (9)
- Nuclear agencies (e.g. the International Atomic Energy Agency (IAEA); Centres for Disease Control and Prevention (CDC)) (10)
- Emergency services (e.g. police; fire brigade) (11)
- Medical staff or resources (12)
- The military (13)
- Other (please specify (14) ____
- Cannot recall (15)

Q10.5 When did you most recently receive this information? (select one)

- During the past year (1)
- 1 to 5 years ago (2)
- 5 to 15 years ago (3)
- More than 15 years ago (4)

Q10.6 Do you feel the information you received prior to 13th January 2018 regarding preparedness and protective actions was sufficient? (select one)

- Yes (1)
- No (2)
- I don't know (3)

Q10.7
If nuclear missiles were fired at Hawai'i, do you believe that the military would be able to intercept them safely?

- yes - we are fully protected (1)
- we are partially protected (2)
- no - we are not protected (3)
- I dont know (4)

End of Block: Preparedness

Start of Block: Preparedness

Q11.1 Would you want to receive information regarding what actions you could take to prepare for a nuclear attack?

- Yes (1)
- No (2)

Skip To: Q11.2 If Would you want to receive information regarding what actions you could take to prepare for a nucl... = Yes

Skip To: Q11.4 If Would you want to receive information regarding what actions you could take to prepare for a nucl... = No

---

Q11.2 When would be the best time for you to receive information regarding preparedness actions to take in a nuclear attack?

- Only when an attack is known to be imminent (1)
- Preferably any time before an attack is known / during peacetime (2)

Q11.3 What one or two things would YOU want to find out to help you prepare for a nuclear attack?

- Specify here: (1) ____

Skip To: Q11.5 If What one or two things would YOU want to find out to help you prepare for a nuclear attack?(Specify here:) Is Not Empty

Q11.4 Why would you not wish to receive information regarding preparedness and protective actions prior to a nuclear attack? (select all that apply)

- I would be too afraid (1)
- I don't believe Hawaiʻi will be attacked with a nuclear device (2)
- I don't believe I could be protected if Hawaiʻi was attacked with a nuclear device (3)
- I do not feel it would be possible to undertake actions that would be advised (4)
- Other (please specify) (5) ____

Q11.5 How likely do you think a nuclear attack on Hawai'i is in your lifetime?

- No risk at all (1)
- A little risk of this happening (2)
- Moderate risk (3)
- Quite a high risk (4)
- Very high risk / quite probable (5)

End of Block: Preparedness

Start of Block: Preparedness

Q12.1 On a scale of 1 -10 what do you perceive to be the effort involved is in carrying out the following preparedness activities?

(1 = very little to no effort involved; 10 = more effort than I would be prepared to take)

(Please note that each slider must be moved to at least the number 1 row to save your response to this question)

	0	1	2	3	4	5	6	7	8	9	10
Obtain a battery powered radio and spare batteries ()											
Store a 14 day supply of food/water ()											
Store a spare supply of medication ()											
Put together a first aid kit ()											
Watch preparedness videos online ()											
Attend (a) town hall meeting(s) about nuclear attack preparedness ()											
Obtain walkie-talkies ()											
Obtain a flashlight (and extra batteries) ()											
Store a bag with cash and important documents ()											
Be prepared to shelter where you are (e.g. at home) for up to 72 hours ()											
Be prepared to shelter where you are (e.g. at home) for up to 1 week ()											
Be prepared to shelter where you (e.g. at home) for up to 2 weeks ()											
Be prepared to evacuate your home to a place of shelter within your town or village ()											
Be prepared to evacuate your home to a place of shelter outside of your town or village ()											

End of Block: Preparedness

Start of Block: Preparedness

Q13.1 Rank the following. Drag sources using your mouse or finger.

Who would you most trust to provide you with information about how to prepare for a nuclear emergency?

Rank 1 = most likely to take this action if recommended; 12 = least likely

______ HIEMA (1)
______ Friends / Family (2)
______ Local authorities (e.g. the Mayor) (3)
______ Federal Government (4)
______ Nuclear agencies (International health protection or nuclear agencies (e.g. the International Atomic Energy Agency (IAEA); Centres for Disease Control and Prevention (CDC)) (5)
______ National news media (6)
______ Online Forums / social media (7)
______ Scientists (8)
______ Emergency services (e.g. police; fire brigade) (9)
______ Medical staff or resources (10)
______ Local news media (11)
______ The military (12)

End of Block: Preparedness

Start of Block: Block 30

Thank you for completing our survey.

Appendix J. Hawai'i survey: Full frequency data

Initial Reaction to the Warning		Frequency	Percentage
How were you first made aware of the ballistic missile warning?	Official warning message from HI-EMA via SMS to cell phone	297	65
	Public warning siren sounding	8	2
	National news (TV/radio)	5	1
	Local news (TV/radio)	20	4
	Word of mouth	92	20
	Other	16	3.5
	I wasn't made aware until I saw the second message informing me it was a false alert	16	3.5
	Total	454	
Where were you upon first receiving the warning?	At home, indoors	327	75
	At work, college, university or school (indoors)	25	6
	Working outdoors	16	4
	In another public area (outdoors) e.g. on the street	49	11
	In another public area (indoors) e.g. in a café	21	5
	Total	438	
Note: Respondents who selected 'I wasn't made aware until I saw the second message informing me it was a false alert' in response to the previous question were not shown this question			
Did you believe that it had been sent by HI-EMA?	Yes	312	69
	No – I believed the warning to be from a source other than HI-EMA	18	4
	No – I believed the warning to be a hoax	63	14
	N/A (I did not hear it until it was known to be a false alarm)	61	13
	Total	454	
Did you believe that an attack was imminent?	Yes	208	53
	No - I believed the warning to be a hoax or a mistake or that it would come to nothing	182	47
	Total	390	

Note: Respondents who selected 'I did not hear it until it was known to be a false alarm' in response to the previous question were not shown this question

Which of the following best describes your immediate response to first hearing the warning?	Frequency	Percentage
Took no action/carried on with what I was doing	87	22
Sought immediate shelter	36	9
Made efforts to verify that the information was correct / the warning was genuine	186	47
Made efforts to find out protective actions I could take	63	16
Immediately initiated a pre-arranged plan	18	4.5
Left home/the place I was at to seek out friends or family	8	2
Got in contact with / tried to get in contact with friends / family using social media or by phone	144	36.5
Other	38	10
Total	394	

Why did you take the action you did upon receiving the ballistic missile warning?	Frequency	Percentage
I felt prepared / knowledgeable as to what actions I should take	36	8
I felt unprepared / lacked knowledge as to what actions I should take	86	19
I wished to verify that the information received was accurate	189	42
I wanted to protect my family	111	24
I wanted to be with family / friends	74	16
I wanted to help others (strangers) who may have been hurt	10	2
My family / friends and I had a pre-arranged meeting place for such an emergency	6	1
I did what the warning advised me to do (regardless of whether I felt it the safest action or not)	21	5
I thought my actions would protect me	28	6
Other	28	6
Total	454	

Please select any ways in which you attempted to find out information as to how to protect self / others following receipt of the warning	Frequency	Percentage
N/A - (I did not seek information about protective actions when I received the warning)	73	16
Searched online (web search)	145	32
Checked on social media	141	31
Contacted HI-EMA	13	3
Contact friends / family	176	39
Contacted another agency / authority	24	5
Other	101	22
Total	454	

Which of the following actions had you taken prior to January 13th 2018 to prepare for an emergency?		Frequency	Percentage
Stored a spare supply of medication	Yes	212	47
	N/A	74	16
Obtained a battery powered radio	Yes	272	60
	N/A	10	2
Stored a 14 day supply of food/water	Yes	202	44
	N/A	4	1
Obtained walkie-talkies	Yes	40	9
	N/A	24	5
Obtained a flashlight (and extra batteries)	Yes	395	87
	N/A	4	1
Put together a first aid kit	Yes	346	76
	N/A	10	2
Stored a bag with cash and important documents	Yes	151	33
	N/A	13	3
Other	Yes	68	15

Thinking of the actions listed on the previous page, did you take these preparedness actions for...		Frequency	Percentage
Stored a spare supply of medication	Nuclear attack	1	0.4
	A different type of emergency (e.g. flooding)	39	18
	No specific emergency (general prep)	124	56
	Not for emergency prep reasons	57	26
Obtained a battery powered radio	A different type of emergency (e.g. flooding)	71	25
	No specific emergency (general prep)	162	58
	Not for emergency prep reasons	47	17
Stored a 14 day supply of food/water	Nuclear attack	1	0.4
	A different type of emergency (e.g. flooding)	65	29
	No specific emergency (general prep)	116	52
	Not for emergency prep reasons	41	18
Obtained walkie-talkies	A different type of emergency (e.g. flooding)	16	16
	No specific emergency (general prep)	43	42
	Not for emergency prep reasons	43	42
Obtained a flashlight (and extra batteries)	Nuclear attack	1	0.3
	A different type of emergency (e.g. flooding)	80	21.5
	No specific emergency (general prep)	233	63
	Not for emergency prep reasons	58	16
Put together a first aid kit	A different type of emergency (e.g. flooding)	56	17
	No specific emergency (general prep)	221	67
	Not for emergency prep reasons	53	16
Stored a bag with cash and important documents	A different type of emergency (e.g. flooding)	29	16
	No specific emergency (general prep)	99	56
	Not for emergency prep reasons	48	27
Other	Nuclear attack	2	2
	A different type of emergency (e.g. flooding)	11	12
	No specific emergency (general prep)	54	57
	Not for emergency prep reasons	28	29

Preparedness information received prior to the false alert		Frequency	Percentage
Prior to January 13th 2018, had you received information regarding general disaster preparedness?	A great deal of information	93	20
	Some information	201	44
	A little information	92	20
	No information	68	15
	Total	454	
Had you received information regarding preparedness and / or protective actions specifically for a nuclear attack?	A great deal of information	23	5
	Some information	92	20
	A little information	107	23.5
	No information	232	51
	Total	454	
Where did your nuclear specific information come from?	Local authorities (e.g. council; mayor's office)	23	10
	Social media	14	6
	Local news media	81	36
	National news media	11	5
	Friends or family	20	9
	National government sources	16	7
	Nuclear agencies	1	0.4
	Emergency services	2	1
	The military	9	4
	Other	29	13
	Cannot recall	16	7
	Total	222	
When did you most recently receive this information?	During the past year	134	60
	1 to 5 years ago	66	30
	6 to 15 years ago	9	4
	More than 15 years ago	13	6
	Total	222	
Do you feel the information you received prior to 13th January 2018 regarding preparedness and protective actions was sufficient?	Yes	71	32
	No	96	43
	I don't know	55	25
	Total	222	

How likely do you think a nuclear attack on Hawai'i is in your lifetime?	Frequency	Percentage
No risk at all	46	10
A little risk	221	49
Moderate risk	135	30
Quite a high risk	32	7
Very high risk / quite probable	20	4
Total	454	

If nuclear missiles were fired at Hawai'i, do you believe that the military would be able to intercept them safely?	Frequency	Percentage
Yes – we are fully protected	64	14
We are partially protected	180	40
No – we are not protected	88	19
I don't know	122	27
Total	454	

Pre-incident communication preferences		Frequency	Percentage
Would you want to receive information regarding what actions you could take to prepare for a nuclear attack?	Yes	379	83
	No	75	16.5
	Total	454	
When would be the best time for you to receive information regarding preparedness actions to take in a nuclear attack?	Only when an attack is known to be imminent	36	9.5
	Preferably any time before an attack is known	343	90.5
	Total	379	
Note: Respondents who selected 'No' in response to the question as to whether they would want to receive pre-incident communications were not shown this question			
Why would you not wish to receive preparedness information?	I would be too afraid	3	4
	I don't believe Hawai'i will be attacked with a nuclear device	8	11
	I don't believe I could be protected if Hawai'i was attacked	43	57
	I do not feel it would be possible to undertake actions advised	5	7
	Other	16	21
	Total	75	

Note: Respondents who selected 'Yes' in response to question as to whether they would want to receive pre-incident communications were not shown this question

Perceived Effort in Undertaking Preparedness Actions

What do you perceive to be the effort involved is in carrying out the following preparedness activities?

1 = very little to no effort involved; 10 = more effort than I would be prepared to take

Rank order of perceived effort (most to least effort)	**Action**	**Mean score**	**Standard Deviation**
1	Be prepared to evacuate your home to a place of shelter outside of your town or village	6.96	2.96
2	Be prepared to shelter where you are (e.g. at home) for up to 2 weeks	6.38	3.2
3	Be prepared to evacuate your home to a place of shelter within your town or village	6.22	3
4	Attend (a) town hall meeting(s) about nuclear attack preparedness	5.55	3.05
5	Be prepared to shelter where you are (e.g. at home) for up to 1 week	5.48	3.3
6	Store a 14 day supply of food/water	5.23	3.34
7	Be prepared to shelter where you are (e.g. at home) for up to 72 hours	4.67	3.48
8	Obtain walkie-talkies	4.53	3.14
9	Store a spare supply of medication	4.27	3.36
10	Store a bag with cash and important documents	4.22	3.37
11	Watch preparedness videos online	3.86	3.05
12	Put together a first aid kit	3.8	3.39
13	Obtain a flashlight (and extra batteries)	3.56	3.65
14	Obtain a battery powered radio and spare batteries	3.56	3.39

Appendix K. Hawai'i survey unadjusted odds ratios for associations with preparedness

Association between predictor variables and individual preparedness

Variable and variable levels	Total preparedness odds ratio (95% CI)
Prior level of disaster preparedness information received	-0.28 (-0.61-0.05)
Prior level of nuclear preparedness information received	-0.09 (-0.5-0.32)
Source of preparedness information	0.04 (-0.03-0.11)
How recently was preparedness information received	**0.35 (0.03-0.67)***
Was preparedness information considered sufficient?	**-0.35 (-0.68—0.01)***
Belief in protection from military	**-0.31 (-0.57—0.05)***
Average low preparedness effort scores	0.04 (-0.06-0.14)
Average high preparedness effort score	-0.11 (-0.24-0.01)

***= Significant result**

Appendix L. Hawai'i survey unadjusted odds ratios for associations with adherence

Associations between predictor variables and individual responses to the alert

Variable and variable levels	No. (%) of participants	No. (% within category) Incidentally adhering to instruction	Incidental adherence unadjusted odds ratio (95% CI)	No. (% within category) deliberately adhering to instruction	Deliberate adherence unadjusted odds ratio (95% CI)
Location upon receiving warning					
Indoors	328 (84)	317 (97)	*Reference*	39 (12)	*Reference*
Outdoors	61 (16)	13 (21)	**0.01* (0.00-0.02)**	12 (20)	1.81 (0.89-3.71)
By what means was the message received?					
SMS from HI-EMA	289 (74)	248 (86)	*Reference*	38 (13)	*Reference*
Warning siren	8 (2)	6 (75)	0.5 (1-2.54)	2 (25)	2.2 (0.43-11.31)
National news	2 (0.5)	2 (100)	*Not Calculated*	0 (0)	*Not Calculated*
Local news	10 (2.5)	10 (100)	*Not Calculated*	2 (20)	1.65 (0.34-8.1)
Word of mouth	69 (18)	55 (80)	0.65 (0.33-1.27)	8 (11.5)	0.87 (0.38-1.95)
Other means	11 (3)	9 (82)	0.74 (0.15-3.57)	1 (9)	0.66 (0.08-5.31)
Was the message believed to be from HI-EMA?					
Yes	308 (79)	257 (83)	*Reference*	45 (15)	*Reference*
No – a different source	18 (5)	16 (89)	1.59 (0.35-7.12)	1 (5.5)	0.34 (0.04-2.65)
No- hoax	63 (16)	57 (90)	1.88 (0.77-4.61)	5 (8)	0.5 (0.19-1.32)
Was an attack believed to be imminent?					
No (hoax or mistake)	181 (46.5)	157 (87)	*Reference*	9 (5)	*Reference*
Yes	208 (53)	173 (83)	0.76 (0.43-1.33)	42 (20)	**4.83* (2.28-10.24)**
Prior level of disaster preparedness information received					
A great deal	75 (19)	62 (83)	*Reference*	6 (8)	*Reference*
Some information	172 (44)	149 (87)	1.36 (0.65-2.85)	28 (16)	2.24 (0.88-5.65)
A little information	84 (21.5)	68 (81)	0.89 (0.4-2)	10 (12)	1.55 (0.54-4.5)
No information	58 (15)	51 (88)	1.53 (0.57-4.11)	7 (12)	1.58 (0.5-4.98)
Prior level of nuclear preparedness information received					
A great deal	22 (6)	19 (86)	*Reference*	5 (23)	*Reference*
Some information	79 (20)	72 (91)	1.62 (0.38-6.88)	15 (19)	0.8 (0.25-2.5)
A little information	91 (23)	70 (77)	0.53 (0.14-1.95)	13 (14)	0.57 (0.18-1.8)
No information	197 (51)	169 (86)	0.95 (0.26-3.43)	18 (9)	0.34 (0.11-1.04)
Belief in protection from military					
Fully protected	57 (15)	50 (88)	*Reference*	11 (19)	*Reference*
Partially protected	148 (38)	125 (84)	0.76 (0.31-1.88)	15 (10)	0.47 (0.2-1.1)
Not protected	77 (20)	68 (88)	1.06 (0.37-3.03)	15 (19)	1.01 (0.42-2.41)
Don't know	107 (27.5)	87 (81)	0.61 (0.24-1.54)	10 (9)	0.43 (0.17-1.09)

Overall level of preparedness	3.71 (mean total)	3.67 (mean within variable)	0.97 (0.84-1.12)	3.76 (mean within variable)	1.02 (0.88-1.2)
Whether a deliberate preparer or not	3.03 (mean total)	3.02 (mean within variable)	0.99 (0.88-1.12)	3.23 (mean within variable)	1.05 (0.92-1.19)
Perceived level of effort involved in sheltering for 72hrs	4.67 (mean total)	4.59 (mean within variable)	0.97 (0.89-1.05)	4.98 (mean within variable)	1.03 (0.95-1.12)

***= Significant result**

Associations between predictor variables and believing an attack to be imminent and with believing an attack to be imminent coupled with adhering to protective instructions / taking protective action

Variable and variable levels	No. (%) of participants	No. (and % within category) of participants believing an attack to be imminent	Adjusted odds ratio (95% CI)	No. (and % within category) of participants believing an attack to be imminent AND adhering to protective instructions	Adjusted odds ratio (95% CI)
Location upon receiving warning					
Indoors	328 (84)	174 (53)	*Reference*	33 (10)	*Reference*
Outdoors	61 (16)	34 (56)	1.11 (0.64-1.93)	9 (15)	1.55 (0.7-3.42)
By what means was the message received?					
SMS from HI-EMA	289 (74)	164 (57)	*Reference*	31 (11)	*Reference*
Warning siren	8 (2)	5 (62.5)	1.27 (0.3-5.42)	2 (25)	2.77 (0.54-14.35)
National news	2 (0.5)	0 (0)	*Not calculated*	0 (0)	*Not calculated*
Local news	10 (2.5)	6 (60)	1.14 (0.32-4.14)	2 (20)	2.08 (0.42-10.24)
Word of mouth	69 (18)	28 (41)	**0.52 (0.3-0.89)***	7 (10)	0.94 (0.39-2.23)
Other means	11 (3)	5 (45)	0.63 (0.19-2.13)	0 (0)	*Not calculated*
Was the message believed to be from HI-EMA?					
Yes	308 (79)	201 (65)	*Reference*	41 (13)	*Reference*
No – a different source	18 (5)	6 (33)	**0.27 (0.1-0.74)***	0 (0)	*Not calculated*
No- hoax	63 (16)	1 (1.5)	**0.01 (0.00-0.06)***	1 (1.5)	**0.1 (0.01-0.78)***
Prior level of disaster preparedness information received					
A great deal	75 (19)	32 (43)	*Reference*	5 (7)	*Reference*
Some information	172 (44)	90 (52)	1.46 (0.84-2.52)	23 (13)	2.16 (0.79-5.92)
A little information	84 (21.5)	47 (56)	1.71 (0.91-3.2)	8 (9.5)	1.47 (0.46-4.72)
No information	58 (15)	39 (67)	**2.76 (1.35-5.63)***	6 (10)	1.61 (0.47-5.58)
Prior level of nuclear preparedness information received					
A great deal	22 (6)	10 (45)	*Reference*	3 (14)	*Reference*
Some information	79 (20)	47 (59)	1.76 (0.68-4.57)	13 (16)	1.25 (0.32-4.84)
A little information	91 (23)	48 (53)	1.34 (0.53-3.41)	9 (9)	0.69 (0.17-2.81)
No information	197 (51)	103 (52)	1.3 (0.54-3.15)	17 (9)	0.6 (0.16-2.23)
Source of preparedness information					
Local authorities	23 (12)	11 (48)	*Reference*	2 (9)	*Reference*
Social media	14 (7)	11 (78.5)	4 (0.88-18.22)	3 (21)	2.86 (0.41-19.77)
Local news media	67 (35)	38 (57)	1.43 (0.55-3.7)	7 (10)	1.22 (0.24-6.37)

National news media	9 (5)	5 (55.5)	1.36 (0.29-6.41)	0 (0)	*Not calculated*
Friends or family	18 (9)	9 (50)	1.09 (0.32-3.75)	2 (11)	1.31 (0.17-10.35)
National government sources1	13 (7)	8 (61.5)	1.74 (0.44-6.97)	2 (15)	1.91 (0.24-15.45)
Nuclear agencies	1 (0.5)	1 (100)	*Not calculated*	0 (0)	*Not calculated*
Emergency services	2 (1)	2 (100)	*Not calculated*	0 (0)	*Not calculated*
The military	7 (4)	3 (43)	0.81 (0.15-4.5)	1 (14)	1.75 (0.13-22.78)
Other	23 (12)	12 (52)	1.19 (0.37-3.78)	6 (26)	3.71 (0.66-20.76)
Cannot recall	15 (8)	5 (33)	0.54 (0.14-2.1)	2 (13)	1.61 (0.2-12.91)
How recently informed of preparedness information					
During the past year	116 (48)	68 (59)	*Reference*	16 (14)	*Reference*
1 – 5 years ago	59 (24)	34 (58)	0.96 (0.51-1.81)	6 (10)	0.71 (0.26-1.91)
6 – 15 years ago	6 (2)	1 (17)	0.14 (0.02-1.25)	1 (17)	1.25 (0.14-11.4)
More than 15 years ago	11 (4.5)	2 (18)	**0.16 (0.03-0.76)**	2 (18)	1.39 (0.27-7.02)
Belief that preparedness information was sufficient					
Yes	59 (31)	24 (41)	*Reference*	6 (10)	*Reference*
No	88 (46)	59 (67)	**2.97 (1.5-5.88)***	16 (18)	1.96 (0.72-5.35)
Don't know	45 (23)	22 (49)	1.39 (0.64-3.05)	3 (7)	0.63 (0.15-2.67)
Belief in protection from military					
Fully protected	57 (15)	30 (53)	*Reference*	10 (17.5)	*Reference*
Partially protected	148 (38)	77 (52)	0.96 (0.52-1.77)	11 (7)	**0.38 (0.15-0.94)***
Not protected	77 (20)	45 (58)	1.26 (0.63-2.52)	11 (14)	0.78 (0.31-1.99)
Don't know	107 (27.5)	56 (52)	0.99 (0.52-1.88)	10 (9)	0.48 (0.19-1.24)
Perceived likelihood of nuclear attack					
No risk at all	35 (9)	11 (31)	*Reference*	4 (11)	*Reference*
A little risk	189 (48.5)	70 (37)	1.27 (0.59-2.75)	13 (9)	0.57 (0.17-1.87)
Moderate risk	118 (30)	88 (74.5)	**6.4 (2.8-14.61)***	14 (12)	1.04 (0.32-3.4)
Quite a high risk	27 (7)	22 (81)	**9.6 (2.88-32.03)***	8 (30)	3.26 (0.86-12.33)
Very high risk	20 (5)	17 (85)	**12.36 (2.99-51.14)***	3 (15)	1.37 (0.27-6.84)

***= Significant result**

Appendix 13. Full UK survey items

Public Attitudes Towards Nuclear Preparedness Communications – A survey study

Welcome to the survey: Public Attitudes Towards Nuclear Preparedness Communications

Before you decide whether you want to take part, please read the information below. If you are happy to continue, please click the button to move to the next page where you will be asked to consent to participation in this research.

Information for participants
My name is Louis Gauntlett and I would like to invite you to take part in this original research project. You should take part only if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important that you understand why the research is being done and what it involves. Please take time to read the following information carefully and discuss it with others if you wish. Ask us to provide information on anything that is not clear or let us know if you would like more information. This study has been approved by the King's College London Research Ethics Review Committee.

What is the purpose of this research?

Evidence suggests that during a radiation emergency, the way in which authorities communicate with the public can influence how people respond to their instructions. When deciding how best to communicate with the public, it is therefore important that we first understand what information needs members of the public have to make sure that we are providing the best information and in the best way.

Who is conducting and funding the research?

The research is being conducted by a joint team from King's College London and Public Health England. This research makes up part of a King's College London PhD project, funded as part of the NIHR Health Protection Research Unit in Emergency Preparedness and Response at King's College London, a partnership with Public Health England, which is the Government agency in England in charge of protecting the public's health during emergencies.

Who is being asked to take part?

We are interested in hearing from members of the public who live in the UK and are 18 years or over.

What will happen if I take part?

If you would like to take part, we will ask you to fill in an on-line questionnaire. The questionnaire takes about 15 minutes to complete and contains questions about any preparedness for a nuclear disaster and information preferences such as source and method of information distribution.

What are the possible benefits of taking part?

Participants will receive X number of Lifepoints upon completion of the survey. In addition, we hope that our results will help us understand how best to communicate with people in the event of a major disaster such as a nuclear attack. We hope this will never happen, but if it does, communicating effectively with people may help them understand what protective actions to take and may help to save lives.

Confidentiality – who will know I am taking part in the study?

Your responses will be completely confidential. The responses you provide will be used within the research study and will be stored on a password protected drive for the duration of this project. Anonymised data may be subject to review by responsible individuals from King's College London for monitoring and audit purposes.

What will happen to the results of the study?

We hope to publish our results (without any personally identifiable information) in a peer-reviewed journal.

Do I have to take part?

No. Your participation in this project is completely voluntary. You may stop participating at any time without giving any reason. If you stop being in the study, there will be no penalty or loss to you. You can do this by closing the link of the survey prior to starting or completing it. Data from unfinished surveys (i.e. those closed prior to completion) will not be used in the final analysis and will be discarded. Each page of the survey will include a 'next' button to move to the next question. Next buttons will only become live once a response is given to the question, by responding to each question and clicking 'finish' at the last page indicates consent for responses to be used in analysis.

If you decide to take part, you will still be free to withdraw your data within two weeks of submitting the survey, without giving a reason.

What happens now?

If this study has harmed you in any way or if you wish to make a complaint about the conduct of the study you can contact King's College London using the details below for further advice and information:

Dr James Rubin gideon.rubin@kcl.ac.uk on +44 020 7848 5684. Address: Department of Psychological Medicine, King's College London, Weston Education Centre, c/o 125 Cold Harbour Lane, London, SE5 9NU

If you wish to contact the research team with a general query about this study then use:
Louis Gauntlett, louis.gauntlett@kcl.ac.uk on +44 020 7848 5684. Address: Department of Psychological Medicine, King's College London, Weston Education Centre, c/o 125 Cold Harbour Lane, London, SE5 9NU

Page Break

End of Block: Introduction page

Start of Block: Consent to take part

If you think you might like to help with this important study and are willing to proceed, please read and check each statement below and select a response from the drop down box below.

I confirm that I am 18 years of age or older

I confirm that I am a UK resident

I have read and understand the information about this project provided above

I understand that my responses will be stored securely for the duration of this research study

I understand that my information may be subject to review by responsible individuals from the College for monitoring and audit purposes

I understand that participation in this study is voluntary and that I am free to withdraw at any time by closing the document

I understand that I am free to request deletion of my responses within two weeks of submitting the survey

I confirm that I have read and understood the information above and I agree to take part in this study

▼ I consent to all of the above items (1) ... I DO NOT consent to all of the above items (2)

Condition: If: I DO NOT consent …. Is selected: skip to end of survey

End of Block: Consent to take part

Start of Block: About you

Q1 **This first section is designed to find out about you.** I am (select one)

- Male (1)
- Female (2)
- Non-binary gender (3)
- Prefer not to say (4)

End of Block: About you

Start of Block: About you

Q2 I am (select one)

- Between 18 – 29 years old (1)
- Between 30 – 39 years old (2)
- Between 40 – 49 years old (3)
- Between 50 – 59 years old (4)
- Between 60 – 69 years old (5)
- 70 years or above (6)
- Prefer not to say (7)

End of Block: About you

Start of Block: About you

Q3 Do you have at least one dependent child? (select all that apply)

- No (1)
- I have a dependent child / children aged under 18 living with me (2)
- I have a dependent child / children aged over 18 living with me (3)
- I have a dependent child / children under 18 but they do not live with me (4)

End of Block: About you

Start of Block: About you

Q4 Do you have any pets?

- Yes (1)
- No (2)

End of Block: About you

Start of Block: About you

Q5 Which of the following best describes your employment status? (select one)

- Employed, working 40 hours or more per week (1)
- Employed, working 1-39 hours per week (2)
- Not employed, looking for work (3)
- Not employed, not looking for work (4)
- Retired (5)
- Disabled, not able to work (6)

End of Block: About you

Start of Block: About you

Q6 What is the highest level of school you have completed or the highest degree you have received? (Select one)

- Left school without qualifications (1)
- Secondary education (O-level/GCSE/A-level) (2)
- Higher education (BSc, BA/higher qualification) (3)
- Prefer not to say (4)

Q7 What is your current geographic location?

Wales

Scotland

Northern Ireland

North East

North West

Yorkshire and The Humber

East Midlands

West Midlands

East

London

South East

South West

End of Block: About you

Start of Block: Risk Perception

Q8 What do you believe to be the likelihood of a catastrophic disaster of any kind (e.g. severe flooding, earthquake, attack from foreign military) occurring anywhere in the UK within your lifetime?

	0 1 2 3 4 5 6 7 8 9 10
(1 = definitely WILL NOT happen in my lifetime; 10 = definitely will happen in my lifetime) ()	

Q9 What do you believe to be the likelihood of a catastrophic disaster of any kind (e.g. severe flooding, earthquake, attack from foreign military) occurring in the UK within your lifetime AND it directly affecting the health of you and/or close family members?

	0 1 2 3 4 5 6 7 8 9 10
(1 = definitely WILL NOT happen in my lifetime; 10 = definitely will happen in my lifetime) ()	

Q10 What do you believe to be the likelihood of a nuclear attack by another country or terrorists occurring anywhere in the UK within your lifetime?

	0 1 2 3 4 5 6 7 8 9 10
(1 = definitely WILL NOT happen in my lifetime; 10 = definitely will happen in my lifetime) ()	

Q11 What do you believe to be the likelihood of a nuclear attack by another country or terrorists occurring in the UK within your lifetime **AND it directly affecting the health of you and/or close family members**?

	0 1 2 3 4 5 6 7 8 9 10
(1 = definitely WOULD NOT directly affect me; 10 = definitely would directly affect me) ()	

End of Block: Risk Perception

Start of Block: Preparedness

Q12 **This section will ask you about your preparedness for an emergency.**

	Which from the list below do you currently have?			If yes, please state why you have this item ?			
	Yes (1)	No (2)	N/A (3)	Nuclear attack (1)	A different type of emergency (e.g. flooding) (2)	No specific emergency (general preparedness) (3)	Not for emergency preparedness reasons (4)
A spare supply of medication (1)	•	•	•	•	•	•	•
A battery powered radio (4)	•	•	•	•	•	•	•
A 14 day supply of food/water (5)	•	•	•	•	•	•	•
A flashlight (and extra batteries) (7)	•	•	•	•	•	•	•
A first aid kit (8)	•	•	•	•	•	•	•
A stored bag with cash and important documents (9)	•	•	•	•	•	•	•
Other preparedness item(s) (please specify) (11)	•	•	•	•	•	•	•

Q13 Have you received information regarding general disaster preparedness? (select one)

- A great deal of information (1)
- Some information (2)
- A little information (3)
- No information (4)

Q14 Have you received information regarding preparedness and / or protective actions you could take before and in the event specifically of a nuclear attack? (select one)

- A great deal of information (1)
- Some information (2)
- A little information (3)
- No information (4)

Condition: 'No information' Is Selected. Skip To: If nuclear missiles were fired at the....(Q19)

Q16 Where did that information come from? (select all that apply)

- Local authorities (e.g. council; mayor's office) (1)
- Social media (2)
- Local news media (3)
- National news media (4)
- Friends / family (5)
- National government sources (6)
- UK nuclear agencies (7)
- International health protection or nuclear agencies (e.g. the International Atomic Energy Agency (IAEA); Centres for Disease Control and Prevention (CDC)) (8)
- Emergency services (e.g. police; fire brigade) (9)
- NHS staff or resources (10)
- The military (11)
- Other (please specify) (12) ____
- Cannot recall (13)

Condition: **'Cannot recall' Is Selected**. Skip To: **If nuclear missiles were fired at the....**(Q19)

Q17 When did you most recently receive this information? (select one)

- During the past year (1)
- 1 to 5 years ago (2)
- 5 to 15 years ago (3)
- More than 15 years ago (4)

Q18 Do you feel the information you received regarding preparedness and protective actions was sufficient? (select one)

- Yes (1)
- No (2)
- I don't know (3)

Q19 If nuclear missiles were fired at the UK, do you believe that the UK military would be able to intercept them safely? (select one)

- yes - we are fully protected (1)
- we are partially protected (2)
- no - we are not protected (3)
- I dont know (4)

End of Block: Preparedness

Start of Block: Preparedness

Q20 Would you want to receive information regarding what actions you could take to prepare for a nuclear attack?

- Yes (1)
- No (2)

Condition: 'No' Is Selected. Skip To: Why would you not wish to receive inf....(Q23)

Q21 When would be the best time for you to receive information regarding preparedness actions to take in a nuclear attack?

- Only when an attack is known to be imminent (1)
- Preferably any time before an attack is known / during peacetime (2)

Q22 What 2 pieces of information would you most want to know in nuclear emergency preparedness materials (choose 2 from the following list)

Information about sheltering (e.g. where to shelter, why sheltering is effective)

Information about evacuating (e.g. where to evacuate, when to evacuate)

Information about how to prepare in advance for a nuclear emergency (e.g. what supplies to keep)

Information about radiation (e.g. what it is, how it affects you)

Information about how you will be given information about an incident (e.g. where to look for trustworthy information, how you will be warned about an incident)

Information specific to nuclear accident (e.g. a nuclear power plant meltdown)

Information specific to a deliberate nuclear incident (e.g. a nuclear bomb)

Information about how to prepare for emergencies more generally (e.g. how to prepare for a flood, or a major storm)

Something else (please say what:…..) (*free text response*)

Q23 Why would you not wish to receive information regarding preparedness and protective actions prior to a nuclear attack? (select all that apply)

I would be too afraid (1)

I don't believe the UK will be attacked with a nuclear device (2)

I don't believe I could be protected if the UK was attacked with a nuclear device (3)

I do not feel it would be possible to undertake actions that would be advised (4)

If an attack happened, the government would provide us with everything we needed (5)

Other (please specify) (6)

Please randomize the order of responses (apart from 'other')

End of Block: Preparedness

Start of Block: preparedness

Q24 On a scale of 1 -10 what do you perceive to be the effort involved in carrying out the following preparedness activities?

(1 = very little to no effort involved; 10 = much more effort than I would be prepared to take)

(Please note that each slider must be moved to at least the number 1 row to save your response to this question)

	0 1 2 3 4 5 6 7 8 9 10
Obtain a battery powered radio and spare batteries ()	
Store a 14 day supply of food/water ()	
Store a spare supply of medication ()	
Put together a first aid kit ()	
Watch preparedness videos online ()	
Be prepared to shelter (e.g. at home) for up to 72 hours ()	
Obtain a torch (and extra batteries) ()	
Store a bag with cash and important documents ()	
Be prepared to shelter where you are (e.g. at home) for up to 1 week ()	
Be prepared to shelter where you (e.g. at home) for up to 2 weeks ()	
Be prepared to leave your home to a place of shelter within your town or village ()	
Be prepared to leave your home to a place of shelter outside of your town or village ()	

End of Block: preparedness

Start of Block: Efficacy

Q25 How **effective** do you feel each of the following actions would be in protecting you should a nuclear attack occur 5 miles from where you are? (0 = I dont know; 1 = not at all effective; 7 = completely effective)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective

	0	1	2	3	4	5	6	7
Sheltering (i.e. remaining inside and building a shelter with furniture) ()								
Building a shelter from furniture (e.g. in your own home)								
Leaving your home to a destination as far away as possible ()								
Leaving your home to a shelter elsewhere in your location (such as the outskirts of town) ()								
Taking Stable Iodine (a tablet used to prevent radiation damage in the thyroid) ()								
Getting underground (e.g. into a basement) ()								
Closing doors and windows at your location ()								

End of Block: Efficacy

Start of Block: Information seeking

Q26 By what method(s) would you prefer to receive information regarding nuclear disaster preparedness (select all that apply)

- Internet / online (1)
- leaflet / letter posted to your residence (2)
- At a local council meeting (4)
- Newspaper (5)
- Television (6)
- Radio (7)
- Word of mouth (8)
- Other (please specify) (9) ____

End of Block: Information seeking

Start of Block: Trust

Q27 Rank the following. Drag sources using your mouse or finger.

Who would you most trust to provide you with information about how to prepare for a nuclear emergency?

Rank 1 = most trusted to provide accurate and effective information; 9 = least likely to provide accurate and effective information

______ National Government (1)
______ Friends / Family (2)
______ Local authorities (e.g. the Mayor, local council) (3)
______ International health protection or nuclear agencies (e.g. the International Atomic Energy Agency (IAEA); Centres for Disease Control and Prevention (CDC)) (4)
______ UK Nuclear agencies (e.g. the Office for Nuclear Regulation) (5)
______ National news media (6)
______ Online forums / Social media (7)
______ Scientists (8)
______ Emergency services (e.g. police; fire brigade) (9)
______ NHS staff or resources (10)
______ Local news media (11)
______ The military (12)

End of Block: Trust

Start of Block: anticipated adherence

Q28 How likely are you to undertake **preparedness actions** (i.e. during a time whilst there is NO KNOWN threat) for a nuclear attack if advised to by each of the following sources?

(1 = extremely unlikely; 10 = extremely likely)

	Extremely unlikely	Moderately unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Moderately likely	Extremely likely

0 1 2 3 4 5 6 7 8 9 10

National Government (e.g. MPs) ()	
Friends / Family ()	
Local authorities (e.g. the Mayor, local council) ()	
International health protection or nuclear agencies (e.g. the International Atomic Energy Agency (IAEA); Centres for Disease Control and Prevention (CDC)) ()	
UK Nuclear agencies (e.g. the Office for Nuclear Regulation) ()	
National news media ()	
Online forums / Social media ()	
Scientists ()	
Emergency services (e.g. police; fire brigade) ()	
NHS staff or resources ()	
Local news media ()	
The military ()	

Q29 How likely are you to undertake **protective actions** (i.e. if threat of attack is known to be imminent or immediately following an attack) for a nuclear attack if advised to by each of the following sources?

(1 = extremely unlikely; 10 = extremely likely)

	Extremely unlikely	Moderately unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Moderately likely	Extremely likely

0 1 2 3 4 5 6 7 8 9 10

National Government (e.g. MPs) ()	
Friends / Family ()	
Local authorities (e.g. the Mayor, local council) ()	
International health protection or nuclear agencies (e.g. the International Atomic Energy Agency (IAEA); Centres for Disease Control and Prevention (CDC)) ()	
UK Nuclear agencies (e.g. the Office for Nuclear Regulation) ()	
National news media ()	
Online forums / Social media ()	
Scientists ()	
Emergency services (e.g. police; fire brigade) ()	
NHS staff or resources ()	
Local news media ()	
The military ()	

End of Block: anticipated adherence

Appendix M. UK survey: Full frequency data

What do you believe to be the likelihood of a catastrophic disaster of any kind (e.g. severe flooding, earthquake, attack from foreign military) occurring anywhere in the UK within your lifetime?	Frequency	Percentage
No risk at all	123	12
A little risk	224	22
Moderate risk	254	25
Quite a high risk	269	26.5
Very high risk / quite probable	144	14
Overall mean average (out of ten)	**5.66**	
Total	**1014**	

What do you believe to be the likelihood of a catastrophic disaster of any kind (e.g. severe flooding, earthquake, attack from foreign military) occurring in the UK within your lifetime AND it directly affecting the health of you and/or close family members?	Frequency	Percentage
No risk at all	186	18
A little risk	272	27
Moderate risk	315	31
Quite a high risk	187	18
Very high risk / quite probable	54	5
Overall mean average (out of ten)	**4.81**	
Total	**1014**	

What do you believe to be the likelihood of a nuclear attack by another country or terrorists occurring anywhere in the UK within your lifetime?	Frequency	Percentage
No risk at all	265	26
A little risk	258	25
Moderate risk	226	22
Quite a high risk	188	18.5
Very high risk / quite probable	77	7.5
Overall mean average (out of 10)	**4.62**	
Total	**1014**	

What do you believe to be the likelihood of a nuclear attack by another country or terrorists occurring in the UK within your lifetime AND it directly affecting the health of you and/or close family members?	Frequency	Percentage
No risk at all	289	28.5
A little risk	254	25
Moderate risk	251	25
Quite a high risk	150	15
Very high risk / quite probable	70	7
Overall mean average (out of 10)	**4.44**	
Total	**1014**	

Which of the following items do you currently have in preparedness for an emergency?		Frequency	Percentage
A spare supply of medication	Yes	402	40
	N/A	80	8
A battery powered radio	Yes	384	38
	N/A	15	1
A 14 day supply of food/water	Yes	352	35
	N/A	13	1
A flashlight (and extra batteries)	Yes	813	80
	N/A	6	0.5
A first aid kit	Yes	747	74
	N/A	7	1
A stored bag with cash and important documents	Yes	249	24.5
	N/A	11	1
Other preparedness items?	Yes	117	11.5

Why do you have this item (listed above)?		Frequency	Percentage
A spare supply of medication	Nuclear attack	13	3
	A different type of emergency (e.g. flooding)	56	14
	No specific emergency (general prep)	263	65
	Not for emergency prep reasons	70	17
A battery powered radio	Nuclear attack	14	4
	A different type of emergency (e.g. flooding)	40	10
	No specific emergency (general prep)	178	46
	Not for emergency prep reasons	152	39.5
A 14-day supply of food/water	Nuclear attack	12	3
	A different type of emergency (e.g. flooding)	51	14
	No specific emergency (general prep)	183	52
	Not for emergency prep reasons	106	30
A flashlight (and extra batteries)	Nuclear attack	12	1
	A different type of emergency (e.g. flooding)	85	10
	No specific emergency (general prep)	483	59
	Not for emergency prep reasons	233	29
A first aid kit	Nuclear attack	11	1
	A different type of emergency (e.g. flooding)	68	9
	No specific emergency (general prep)	486	65
	Not for emergency prep reasons	182	24
A bag with cash and important documents	Nuclear attack	12	5
	A different type of emergency (e.g. flooding)	41	16
	No specific emergency (general prep)	136	55
	Not for emergency prep reasons	60	24
Other	Nuclear attack	5	4
	A different type of emergency (e.g. flooding)	24	20.5
	No specific emergency (general prep)	68	58
	Not for emergency prep reasons	20	17

Prior preparedness information received		Frequency	Percentage
Have you received information regarding general disaster preparedness?	A great deal of information	25	2
	Some information	113	11
	A little information	104	10
	No information	772	76
Have you received information regarding preparedness and / or protective actions specifically for a nuclear attack?	A great deal of information	35	3
	Some information	86	8
	A little information	78	8
	No information	815	80
Where did your nuclear specific information come from?	Local authorities (e.g. council; mayor)	34	17
	Social media	50	25
	Local news media	36	18
	National news media	45	23
	Friends or family	49	25
	National government sources	45	23
	UK nuclear agencies	18	9
	International health protection or nuclear agencies	21	11
	Emergency services	36	18
	NHS staff or resources	28	14
	The military	27	14
	Other	8	5.5
	Cannot recall	22	11
	Total	199	
When did you most recently receive this information?	During the past year	34	19
	1 to 5 years ago	79	45
	6 to 15 years ago	33	19
	More than 15 years ago	31	17.5
	Total	177	
Do you feel the information you received regarding preparedness and protective actions was sufficient?	Yes	92	52
	No	61	34
	I don’t know	24	13.5
	Total	177	

If nuclear missiles were fired at the UK, do you believe that the UK military would be able to intercept them safely?	Frequency	Percentage
Yes – we are fully protected	124	12
We are partially protected	432	43
No – we are not protected	225	22
I don't know	233	23
Total	1014	

Pre-incident communication preferences		Frequency	Percentage
Would you want to receive information regarding what actions you could take to prepare for a nuclear attack?	Yes	738	73
	No	276	27
	Total	1014	
When would be the best time for you to receive information regarding preparedness actions to take in a nuclear attack?	Only when an attack is known to be imminent	190	26
	Preferably any time before an attack is known	548	74
	Total	738	

Note: Respondents who selected 'No' in response to the question as to whether they would want to receive pre-incident communications were not shown this question

Why would you not wish to receive information regarding preparedness and protective actions prior to a nuclear attack?	I would be too afraid	32	12
	I don't believe the UK will be attacked with a nuclear device	94	34
	I don't believe I could be protected if the UK was attacked with a nuclear device	116	42
	I do not feel it would be possible to undertake actions that would be advised	67	24
	If an attack happened, the government would provide us with everything we needed	33	12
	Other	13	5

Note: Respondents who selected 'Yes' in response to question as to whether they would want to receive pre-incident communications were not shown this question

What 2 pieces of information would you most want to know in nuclear emergency preparedness materials?	Information about sheltering	293	29
	Information about evacuating	224	22
	Information about how to prepare in advance for a nuclear emergency	302	30
	Information about radiation	117	11.5
	Information about how you will be given information about an incident	153	15
	Information specific to nuclear accident	91	9

	Information specific to a deliberate nuclear incident	78	8
	Information about how to prepare for emergencies more generally	214	21
	Something else	4	0.4
By what method(s) would you prefer to receive information regarding nuclear disaster preparedness?	Internet / online	586	58
	Leaflet / letter posted to your residence	622	61
	At a local council meeting	102	10
	Newspaper	232	23
	Television	559	55
	Radio	319	31
	Word of mouth	104	10
	Other	18	2

Appendix N. UK survey unadjusted odds ratios for associations with preparedness

Association between personal variables and intentional preparedness

Variable and variable levels	No. (%) of participants	No. (% within variable level) classified as intentionally disaster prepared	Unadjusted odds ratio (95% CI)
Gender			
Male	503 (50)	205 (41)	*Reference*
Female	507 (50)	201 (40)	0.95 (0.74-1.23)
Non-binary gender	2 (0.2)	0 (0)	*Not calculated*
Prefer not to say	2 (0.2)	1 (50)	1.45 (0.09-23.37)
Age			
18-29	166 (16)	79 (47.5)	*Reference*
30-39	163 (16)	64 (39)	0.73 (0.47-1.13)
40-49	176 (17)	53 (30)	**0.49 (0.31-0.76)***
50-59	185 (18)	76 (41)	0.79 (0.51-1.2)
60-69	168 (16.5)	66 (39)	0.73 (0.47-1.13)
70+	155 (15)	69 (44.5)	0.9 (0.58-1.4)
Prefer not to say	1 (0.1)	1 (100)	*Not calculated*
Dependent Children			
None	675 (66.5)	239 (35)	*Reference*
Children <18 living with me	262 (26)	136 (52)	**1.97 (1.47-2.63)***
Children >18 living with me	53 (5)	19 (36)	1.02 (0.57-1.83)
Children not living with me	24 (2)	13 (54)	2.16 (0.95-4.89)
Pets			
Yes	538 (53)	242 (45)	*Reference*
No	476 (47)	165 (35)	**0.65 (0.5-0.84)***
Geographic Location			
Outside of London	889 (88)	354 (40)	*Reference*
London	125 (12)	53 (42)	1.11 (0.76-1.63)
Employment			
Not Employed	452 (44.5)	179 (40)	*Reference*
Employed	562 (55)	228 (40.5)	1.04 (0.81-1.34)
Education level			
Left school without qualifications	59 (6)	24 (41)	*Reference*
Secondary education	466 (46)	167 (36)	0.81 (0.47-1.42)
Higher education	488 (48)	216 (44)	1.16 (0.67-2.01)

***= Significant result**

Association between predictor variables and intentional preparedness

Variable and variable levels	No. (%) of participants	No. (% within variable level) classified as intentionally disaster prepared	Unadjusted odds ratio (95% CI)
General disaster risk perception			
No risk at all	123 (12)	45 (36.5)	*Reference*
A little risk	224 (22)	69 (31)	0.77 (0.48-1.23)
Moderate risk	254 (25)	98 (38.5)	1.09 (0.7-1.7)
Quite a high risk	269 (26.5)	114 (42)	1.27 (0.82-1.98)
Very high risk / quite probable	144 (14)	81 (56)	**2.23 (1.36-3.65)***
General disaster (with direct effect) risk perception			
No risk at all	186 (18)	57 (31)	*Reference*
A little risk	272 (27)	91 (33)	1.14 (0.76-1.7)
Moderate risk	315 (31)	132 (42)	**1.63 (1.11-2.4)***
Quite a high risk	187 (18)	90 (48)	**2.1 (1.37-3.21)***
Very high risk / quite probable	54 (5)	37 (68.5)	**4.93 (2.56-9.47)***
Nuclear attack risk perception			
No risk at all	265 (26)	95 (36)	*Reference*
A little risk	258 (25)	79 (31)	0.79 (0.55-1.14)
Moderate risk	226 (22)	94 (41.5)	1.27 (0.88-1.83)
Quite a high risk	188 (18.5)	91 (48)	**1.68 (1.15-2.46)***
Very high risk / quite probable	77 (7.5)	48 (62)	**2.96 (1.75-5.01)***
Nuclear attack risk perception (with direct effect)			
No risk at all	289 (28.5)	97 (33.5)	*Reference*
A little risk	254 (25)	83 (33)	0.96 (0.67-1.37)
Moderate risk	251 (25)	102 (41)	1.35 (0.95-1.92)
Quite a high risk	150 (15)	81 (54)	**2.32 (1.55-3.48)***
Very high risk / quite probable	70 (7)	44 (63)	**3.35 (1.95-5.76)***
General preparedness information			
A great deal	25 (2)	23 (92)	*Reference*
Some information	113 (11)	85 (75)	0.26 (0.06-1.91)
A little information	104 (10)	58 (56)	**0.11 (0.02-0.49)***
No information	772 (76)	241 (31)	**0.04 (0.01-0.17)***
Nuclear preparedness information			
A great deal	35 (3)	28 (80)	*Reference*
Some information	86 (8)	63 (73)	0.68 (0.26-1.78)
A little information	78 (8)	38 (49)	**0.24 (0.09-0.61)***
No information	815 (80)	278 (34)	**0.13 (0.06-0.3)***
Source of preparedness information			
Local authorities	34 (17)	27 (79)	2.38 (0.98-5.79)
Social media	50 (25)	38 (76)	2.02 (0.97-4.18)
Local news media	36 (18)	30 (83)	**3.23 (1.27-8.2)***
National news media	45 (23)	35 (78)	**2.23 (1.03-4.84)***
Friends or family	49 (25)	36 (73)	1.7 (0.83-3.47)
National government sources	45 (23)	31 (69)	1.26 (0.62-2.58)
UK nuclear agencies	18 (9)	13 (72)	1.46 (0.5-4.27)
International nuclear agencies	21 (10.5)	17 (81)	2.5 (0.8-7.76)
Emergency services	36 (18)	31 (86)	**4.11 (1.52-11.12)***

NHS	28 (14)	22 (78.5)	2.19 (0.84-5.7)
The military	27 (13.5)	22 (81)	2.67 (0.96-7.4)
Other	11 (5.5)	4 (36)	0.29 (0.08-1.02)
Cannot recall	22 (11)	8 (36)	0.26 (0.1-0.67)
How recently informed			
During the past year	34 (19)	24 (70.5)	*Reference*
1 – 5 years ago	79 (45)	60 (76)	1.32 (0.53-3.24)
6 – 15 years ago	33 (19)	21 (64)	0.73 (0.26-2.03)
More than 15 years ago	31 (17.5)	16 (52)	0.44 (0.16-1.23)
Information sufficiency			
Yes	92 (52)	76 (83)	*Reference*
No	61 (34)	32 (52)	**0.23 (0.11-1.48)***
Don't know	24 (13.5)	13 (54)	**0.25 (0.09-0.65)***
Belief in protection from military			
Fully protected	124 (12)	76 (61)	*Reference*
Partially protected	432 (43)	189 (44)	**0.49 (0.33-0.74)***
Not protected	225 (22)	75 (33)	**0.32 (0.2-0.5)***
Don't know	233 (23)	67 (29)	**0.25 (0.16-0.4)***
Low perceived preparedness effort	3.65 (Mean total)	3.95 (Mean within variable)	**1.13 (1.06-1.21)***
High perceived preparedness effort	5.35 (Mean total)	5.51 (Mean within variable)	**1.06 (1-1.13)***
Sheltering Effectiveness	2.74 (Mean total)	3.2 (Mean within variable)	**1.25 (1.16-1.34)***

***= Significant result**

Association between predictor variables and individual preparedness

Variable and variable levels	Total preparedness: odds ratio (95% CI)
Prior level of general disaster preparedness information received	**-0.69 (-0.82-0.56)***
Prior level of nuclear preparedness information received	**-0.6 (-0.73-0.47)***
Source of preparedness information: Local authorities	0.44 (-0.2-1.07)
Source of preparedness information: Social media	0.23 (-0.32-0.78)
Source of preparedness information: Local news media	**0.79 (-0.18-1.41)***
Source of preparedness information: National news media	0.37 (-0.2-0.94)
Source of preparedness information: Friends / family	0.49 (-0.06-1.05)
Source of preparedness information: National government	0.54 (-0.03-1.1)
Source of preparedness information: UK nuclear agencies	0.44 (-0.39-1.28)
Source of preparedness information: International nuclear agencies	**1.03 (0.27-1.8)***
Source of preparedness information: Emergency services	1.12 (0.52-1.73)
Source of preparedness information: NHS	0.4 (-0.29-1.09)
Source of preparedness information: The military	0.74 (0.05-1.43)
Source of preparedness information: Other	-0.33 (-1.38-0.72)
Source of preparedness information: Cannot recall	**-1 (-1.75--0.25)***
How recently was preparedness information received	-0.25 (-0.51-0.00)
Was preparedness information considered sufficient?	**-0.57 (-0.92--0.22)***
Belief in protection from military	**-0.38 (-0.49--0.28)***
Average low preparedness effort scores	0.01 (-0.04-0.06)
Average high preparedness effort score	0.00 (-0.04-0.05)

***= Significant result**

Appendix O. UK survey unadjusted odds ratios for associations with pre-incident communications preferences

Association between personal variables and desire for pre-incident communications

Variable and variable levels	No. (%) of participants	No. (% within variable level) who desire pre-incident communications	Unadjusted odds ratio (95% CI)
Gender			
Male	503 (50)	359 (71)	*Reference*
Female	507 (50)	375 (74)	0.88 (0.66-1.16)
Non-binary gender	2 (0.2)	2 (100)	*Not calculated*
Prefer not to say	2 (0.2)	2 (100)	*Not calculated*
Age			
18-29	166 (16)	133 (80)	*Reference*
30-39	163 (16)	127 (78)	1.14 (0.67-1.94)
40-49	176 (17)	122 (69)	**1.78 (1.08-2.93)***
50-59	185 (18)	118 (64)	**2.29 (1.41-3.72)***
60-69	168 (16.5)	121 (72)	1.56 (0.94-2.6)
70+	155 (15)	116 (75)	1.35 (0.8-2.29)
Prefer not to say	1 (0.1)	1 (100)	*Not calculated*
Dependent Children			
None	675 (66.5)	478 (71)	*Reference*
Children <18 living with me	262 (26)	199 (76)	0.77 (0.55-1.07)
Children >18 living with me	53 (5)	42 (79)	0.63 (0.32-1.26)
Children not living with me	24 (2)	19 (79)	0.64 (0.23-1.73)
Pets			
Yes	538 (53)	405 (75)	*Reference*
No	476 (47)	333 (70)	1.31 (0.99-1.72)
Geographic Location			
Outside of London	889 (88)	650 (73)	*Reference*
London	125 (12)	88 (70)	1.14 (0.76-1.73)
Employment			
Not Employed	452 (44.5)	334 (74)	*Reference*
Employed	562 (55)	404 (72)	1.11 (0.84-1.46)
Education level			
Left school without qualifications	59 (6)	42 (71)	*Reference*
Secondary education	466 (46)	335 (72)	0.97 (0.53-1.76)
Higher education	488 (48)	361 (74)	0.87 (0.48-1.58)
Prefer not to say	1 (0.1)	0 (0)	*Not calculated*

***= Significant result**

Association between predictor variables and desire for pre-incident communications

Variable and variable levels	No. (%) of participants	No. (% within variable level) who desire pre-incident communications	Unadjusted odds ratio (95% CI)
General disaster risk perception			
No risk at all	123 (12)	68 (55)	*Reference*
A little risk	224 (22)	160 (71)	**0.49 (0.31-0.78)***
Moderate risk	254 (25)	172 (68)	**0.59 (0.38-0.92)***
Quite a high risk	269 (26.5)	218 (81)	**0.29 (0.18-0.46)***
Very high risk / quite probable	144 (14)	120 (83)	**0.25 (0.14-0.43)***
General disaster (with direct effect) risk perception			
No risk at all	186 (18)	107 (57.5)	*Reference*
A little risk	272 (27)	193 (71)	**0.55 (0.37-0.82)***
Moderate risk	315 (31)	238 (75.5)	**0.44 (0.3-0.65)***
Quite a high risk	187 (18)	155 (83)	**0.28 (0.17-0.45)***
Very high risk / quite probable	54 (5)	45 (83)	**0.27 (0.12-0.59)***
Nuclear attack risk perception			
No risk at all	265 (26)	169 (64)	*Reference*
A little risk	258 (25)	171 (66)	0.9 (0.62-1.28)
Moderate risk	226 (22)	179 (79)	**0.46 (0.31-0.69)***
Quite a high risk	188 (18.5)	154 (82)	**0.39 (0.25-0.61)***
Very high risk / quite probable	77 (7.5)	65 (84)	**0.32 (0.17-0.63)***
Nuclear attack risk perception (with direct effect)			
No risk at all	289 (28.5)	182 (63)	*Reference*
A little risk	254 (25)	174 (68.5)	0.78 (0.55-1.12)
Moderate risk	251 (25)	193 (77)	**0.51 (0.35-0.75)***
Quite a high risk	150 (15)	125 (83)	**0.34 (0.21-0.56)***
Very high risk / quite probable	70 (7)	64 (91)	**0.16 (0.07-0.38)***
How recently informed			
During the past year	34 (19)	30 (88)	*Reference*
1 – 5 years ago	79 (45)	71 (90)	0.84 (0.24-3.02)
6 – 15 years ago	33 (19)	24 (73)	2.81 (0.77-10.26)
More than 15 years ago	31 (17.5)	28 (90)	0.8 (0.16-3.91)
Information sufficiency			
Yes	92 (52)	86 (93)	*Reference*
No	61 (34)	49 (80)	**3.051 (1.24-9.94)***
Don't know	24 (13.5)	18 (75)	**4.78 (1.38-16.52)***
Belief in protection from military			
Fully protected	124 (12)	94 (76)	*Reference*
Partially protected	432 (43)	336 (78)	0.89 (0.56-1.43)
Not protected	225 (22)	150 (67)	1.57 (0.95-2.57)
Don't know	233 (23)	158 (68)	1.49 (0.91-2.44)
Low perceived preparedness effort	3.65 (Mean total)	3.76 (Mean within variable)	**0.9 (0.83-0.97)***
High perceived preparedness effort	5.35 (Mean total)	5.37 (Mean within variable)	0.98 (0.92-1.05)
Sheltering Effectiveness	2.74 (Mean total)	2.88 (Mean within variable)	**0.86 (0.8-0.93)***

***= Significant result**